THE ENGINEER

FEBRUARY 5, 1954

Society of Engineers

THIS year the Society of Engineers celebrates its centenary and in the course of his presidential address on Monday last, Mr. W. R. Howard traced the origin and growth of the Society. It was founded in May, 1854, and, as it was set up as a means of reunion for former students of Putney College by two engineers, Mr. Robert Munro Christie and Mr. Henry Palfrey Stephenson, with six others, it was given the title of the "Putney Club." The first meetings were held at "Mr. Talmadje's," 221, The Strand, but in the November of 1854 the meeting place was changed to Mr. Christie's offices at 76, King William Street, in the City. It appears that in the early meetings various points of engineering practice were discussed in an atmosphere of informality. The custom of reading and discussing papers was introduced at the first meeting in 1855, with a paper by the first president, Mr Stephenson, on "The Rise and Fall of Putney College." At the annual general meeting in December, 1857, the name was changed from the Putney Club to the Society of Engineers. In 1907, Mr. A. S. E. Ackerman, who had been secretary of the Civil and Mechanical Engineers' Society since 1898, also became secretary of the Society of Engineers, and in 1910 the two societies amalgamated under the name of the Society of Engineers (Incorporated). Each interesting important event, and many of the personalities associated with the history of the Society, were dealt with by Mr. Howard, before he turned his attention to the part of his address dealing with his own particular branch of engineering—ferro-concrete. Mr. Howard first traced the evolution of ferro-concrete and then dealt in detail with auto-stressing of concrete with expanding cements, aluminous cements, improvements in quality of concrete, special concretes, prestressed concrete and steel reinforcement in concrete.

American Research

THE British Commonwealth Scientific Office in Washington makes an annual review of American scientific progress, and its latest report, which is entitled *Science in U.S.A.*, and which covers the twelve months ended June, 1953, has now been published. This report says that in the preceding year Federal expenditure on research was 1800 million dollars, but that in the year ended June last the sum expended was probably 2200 million dollars. Only about 25 per cent of the total, however, was spent on research in Government stations, 15 per cent being expended for work in non-profit-making institutions and 60 per cent for work done by profit-making organisations. In a section of the report dealing with scientific and technological manpower it is stated that about 5,000,000 people are engaged in scientific and professional work in the U.S.A. More than 1,000,000 are teachers, nearly 1,000,000 are engaged in the medical and health services, and over 500,000 are engineers. There are approximately 155,000 workers in the natural sciences, about 15,000 of them being engaged on fundamental research. Nevertheless, it is considered that there is still a shortage of some kinds of scientific manpower, the report quoting as an example the opinion that 80,000 more engineers could be employed. Reference is also made in the report to the wasteful employment of professional manpower, one complaint being that too many engineers are doing work which does not fully exercise their engineering talent, and that others who are doing the work for which they have been trained are being hampered by routine duties. In the sections of the report dealing with particular aspects of research work in the U.S.A., it is stated that, during the year reviewed, the Atomic Energy Commission spent about 300 million dollars on research and development. Last June, the report records, it was announced that it had been found possible to produce fissionable plutonium from non-fissionable uranium 238 at least equal in quantity to the fissionable uranium 235 which is consumed in the process. The report is available in this country from H.M. Stationery Office, price 2s.

Example of the Plastic Method of Structural Design

AN example of a practical application of the plastic method of design for steel structures was given in a paper presented at the Institution of Structural Engineers on January 28th, entitled "Design and Construction of a Welded Portal Frame Warehouse Building Designed by the Plastic Method," by E. J. Callard. This method of design, as is well known, was first developed by a research team headed by Professor J. F. Baker, and has reached the stage where a number of examples of its application to everyday structural problems may be cited. Mr. Callard described the design for a simple portal frame building intended for storage, which was "to serve the simplest purpose—to provide shelter from wind, sun and excessively high or low temperatures—and was free of all platforms and other loads." The building consists of uniform-section (10in by 4½in by 25lb per foot R.S.J.s), all-welded pitched portal frames, having fixed bases and spanning 60ft, and having a height of 15ft to the eaves; the frames were spaced 15ft apart, with a light roof covering and brick walls, the building being 195ft long, with fourteen portal frames altogether. A comparison was made between this design and an elastic design for the same structure, both methods being based on B.S.S. 449, to give a true comparison. The total weight of steel in the fourteen frames is 18·6 tons, and the elastic design gave a figure of 28·4 tons, so that an economy of 34·5 per cent was achieved. Further economy would have resulted, the author pointed out, had the full advantage been taken of the extreme light weight of the roof cladding, which would have reduced the figure given above to 15·8 tons. The purlins and column ties accounted for 19·35 tons, so that the total steel in the building, as erected, excluding reinforcement in the foundations, was about 33 tons.

Operational Research Society

THE Operational Research Club, which was founded five years ago, and the membership of which has been restricted to a comparatively small number, has been reconstituted as the Operational Research Society. There is no numerical limit of membership, but members of the Society must be engaged, of course, in some form of operational research. The objects of the Society are "the advancement of education through the provision of training in and the promotion and adoption of the knowledge of operational research," and the annual subscription is 25s. The first chairman of the Society is Dr. O. H. Wansbrough-Jones, chief scientist in the Ministry of Supply, and other members of the committee are Dr. T. E. Easterfield, of the Department of Scientific and Industrial Research; Sir Charles Goodeve, of the British Iron and Steel Research Association; Mr. Donald Hicks, of the National Coal Board; and Mr. A. W. Swan, of Courtaulds, Ltd. Mr. B. H. P. Rivett, 2, Grosvenor Place, London, S.W.1, is the Society's honorary secretary. A recent survey, which was published in *Operational Research Quarterly*, the Society's official journal, claims that there are now "over forty organisations having sections whose major activity may be classified as operational research, although less than half of them use that term in the name of their group." In addition, it is stated, about the same number carry out operational research in one or other of the parts of their organisations at some time or other.

Incorporated Plant Engineers' Dinner

THE second annual dinner of the Institution of Incorporated Plant Engineers was held in London last Friday evening, and was attended by a large company of members and guests. Mr. J. C. Veale, the president, was in the chair. The toast of "The Institution" was proposed by Sir Hubert Houldsworth, Q.C., chairman of the National Coal Board, who said that although these were days of increasing specialisation, plant engineers needed to have some knowledge of all branches of engineering. He believed that there was still a place for developing originality, although it was not always appreciated at its true worth. Sir Hubert went on to talk about the development of technological training, which he described as the country's greatest need, and said that it was now more important than ever that the highest efficiency should be achieved in every aspect of engineering. Referring in particular to the efficient use of the nation's fuel resources, Sir Hubert said that last year's production of coal in this country was only achieved by the loss by death of 364 men out of an average number of 717,000 engaged in the mining industry and serious injury to 1904 others. Those figures, Sir Hubert observed, were still high, although combined they were the lowest on record. He felt sure that it was the duty of all who used coal or its derivatives to reflect on such figures and to seek to use fuel intelligently and with the minimum of waste. The toast was acknowledged by the president, after which Sir Henry Wilson Smith, K.C.B., proposed the toast of "The Guests." Responses to that toast were made by Sir Charles Ellis, F.R.S., and Sir John Cockcroft, F.R.S.

Post-Graduate Technical Courses

THE Regional Advisory Council for Higher Technological Education in London and the Home Counties has published its fifth annual report, which surveys the year ended August 31, 1953. The report says that the Council has evidence that many science and engineering graduates besides those with "special ability" in the academic sense, require additional technological education for the line in industry which they intend to pursue. Men and women entering industry with a general honours degree in science often find, according to the Council, that the particular scientific principles governing the actual problems confronting them in industry have received scant treatment during the first degree course. It is therefore desirable, the report continues, for many graduates, who would possibly never qualify as Master or Doctor, to take a post-graduate course preferably after two or more years' industrial experience. Often such cases are met by a part-time course of evening lectures, but sometimes the additional studies require a full-time course of as much as one academic year. The Council realises that a full-time course for a graduate who has already taken a post in industry brings its own problems. Experience has shown that firms which are sympathetic and even enthusiastic about such schemes in principle find it difficult, in practice, to release a man of graduate status for as long as twelve months to improve his basic qualifications. Nevertheless, the hope is expressed in the report that industry will realise increasingly that the temporary loss of a graduate's services will be more than compensated by his greater opportunities of serving the interests both of his firm and of the country after a year of post-graduate training illuminated by works experience.

High Temperature Turbine Machinery for Marine Propulsion

By T. W. F. BROWN, D.Sc., S.M., M.I.E.E.*

No. III—GAS TURBINES

(*Concluded from page* 161, *January* 29*th*)

In these concluding abstracts reprinted from the Thomas Lowe Gray lecture, presented by the author before the Institution of Mechanical Engineers on Friday, January 15*th, the development of the gas turbine for marine use is discussed. The cooled gas turbine is particularly studied and shown to have greater potentialities for improvement than the steam turbine.*

Cycle Calculations

To obtain estimates of the performance of a high temperature, liquid cooled gas turbine, cycle calculations have been carried out for a practicable design of this type. Cooling losses were calculated in detail using the methods given in Brown (1950a and 1951). It was assumed that the blade temperature could be maintained at 1200 deg. Fah. in all cooled stages by appropriate design of the cooling system. Fig. 14 shows the cooling loss (as a percentage of the work done) for a turbine stage operating at 1 atm. gas pressure and at various gas temperatures, and Fig. 15 shows how the total cooling loss so determined varies with pressure at the same range of temperature. It will be seen that high pressure is associated with lower cooling loss. Cycle calculations also show that high temperatures require high pressure ratios.

One more consideration has to be taken into account before cycle calculations can begin. As shown in the earlier paper (Brown 1950a) cooling loss is equivalent to a negative reheat factor. A basic turbine efficiency of 83 per cent has been assumed. The variation of turbine efficiency in relation to cooling loss and pressure ratio was calculated. It will be found that at a basic efficiency of 83 per cent the effect of reheat due to losses and of cooling loss cancels out when the cooling loss is 20 per cent. The expansion line is then isentropic. The other assumptions made are given in Table VIII.

TABLE VIII—*Assumptions Made in Cycle Calculations*

Compressor efficiency assumed, per cent	85
Combustion efficiency, per cent	98
Heat exchanger effectiveness, per cent	(*a*) Zero (*b*) 75
Ambient air temperature, degrees Fahrenheit	60
Temperature after intercooler, degrees Fahrenheit	70
Pressure drops :	
Intercooler, per cent	2
Combustion system, per cent	2
Inlet and outlet ducts, total, per cent	1
Heat exchanger if fitted, total, per cent	4½

The nominal pressure ratio examined= (pressure at high pressure compressor discharge)/(compressor inlet pressure).

From experience the cycle chosen for examination in this lecture is a three-turbine arrangement as shown in Fig. 13. This cycle was carefully considered in 1946 and submitted to the Admiralty for a scheme to operate at a lower temperature and, therefore, reheat was used between the high-pressure and intermediate-pressure turbines. The high-pressure turbine drives the high-pressure compressor ; the intermediate-pressure turbine is the output turbine and the low-pressure turbine drives the low-pressure compressor. One stage of intercooling is used. Precooling of the low-pressure inlet air can be added if ambient conditions permit. The combined low-pressure unit (turbine and compressor) could be regarded as a supercharger which can be put out of action during part-load running. The effect with and without a heat exchanger of a thermal ratio of 75 per cent was also examined. The conditions at full load are not affected by the particular configuration shown in Fig. 13 ; that is, at full load, the turbines driving compressors could be interchanged without changing the results.

These investigations are best summarised by the use of two sets of curves. Fig. 16 shows the effects of pressure ratio at a constant temperature of 2200 deg. Fah. with and without cooling losses and with

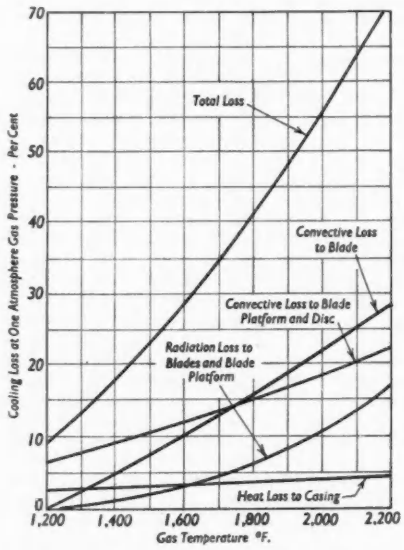

Cooling Loss at One Atmosphere Gas Pressure - Per Cent
Gas Temperature °F.
Total Loss
Convective Loss to Blade
Convective Loss to Blade Platform and Disc
Radiation Loss to Blades and Blade Platform
Heat Loss to Casing

Fig. 14—Estimated Cooling Losses per Stage at 1 Atm. Gas Pressure for Liquid-Cooled Gas Turbine with Ceramic Nozzles and Ceramic-Lined Casing

and without a heat exchanger. If no heat exchanger is used the maximum thermal efficiency, allowing for cooling losses, occurs at a pressure ratio of over 100 which would require three compressors in series. Without long component trials the matching problems involved could be shortened only by having three compressor drive turbines and the complexity of the set would be greatly increased. It is clear that, if the aim is maximum thermal efficiency without the need for excessive compression ratios, a heat exchanger is necessary.

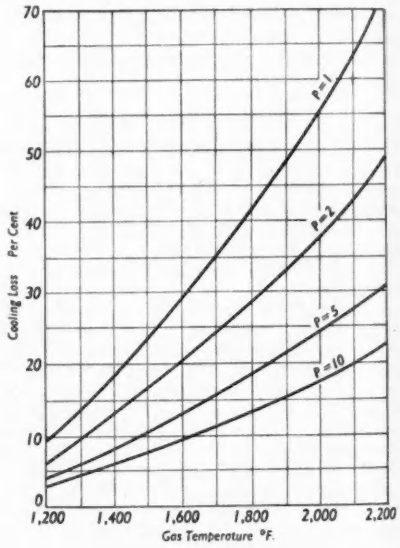
Fig. 18 shows the effect of temperature at any pressure ratio in relation to thermal efficiency. On each of these sets of curves the air rate is given which is a measure of the size of the installation and of the ducts and piping in relation to the net power developed. In all these instances it has been assumed that the cooling loss in the gas turbine is not used. It is, of course, possible to recover some of the cooling loss if steam is generated and utilised. The investigation of this was made by Brown (1950a) who showed that combined thermal efficiencies of gas and steam plants reach a peak of 49 per cent thermal efficiency when a regenerative heat exchanger of a thermal ratio of 0·95 is used. Despite further work, the earlier curves and findings in relation to water cooling (Brown 1950a) are entirely consistent with those now given.

Some Practical Considerations

Compressors.—The axial-flow type of compressor is the most likely to be used in marine applications as it is small in relation to its throughput when compared with multi-stage centrifugal compressors. Fouling has not been the problem which it was feared it would be. From the air rate figure it can be seen that the size of compressors in relation to net output is greatly reduced (by, say, a factor of 3 or more) at high temperatures. At a pressure ratio of 36 the pressure ratio of each compressor is 6, which is about the practical limit for an axial compressor of high efficiency at this time. No change in compressors other than the use of all the improvements at present available is required.

Intercoolers.—The main problem is the removal of water from the cooled air before it passes to the next compressor.

Combustion Chambers.—At an outlet temperature of 2200 deg. Fah. the air/fuel ratio would be 40 with an air inlet temperature of 700 deg. Fah, or 50 at 1000 deg. Fah. Porous wall cooling could be used in place of refractory lining, since no thermodynamic loss arises so long as the dilution occurs upstream of the turbine and temperature striations in the gas stream are not caused. It should be clear that cycle efficiency depends on the mean temperature of the inlet gas to the turbine, although robustness is dependent on the maximum temperature impinging on a



P, gas pressure at stage in atm.

Fig. 15—Estimated Total Cooling Loss per Stage in Liquid-Cooled Gas Turbine at Various Pressures

section of the turbine such as nozzles, blading, &c. This is why a great deal of attention is paid to a good temperature distribution at the turbine inlet.

Turbine.—Little can be said about the design of the turbine at this time, although the author can report that a single-stage turbine to operate at 2200 deg. Fah. is now under construction for the Admiralty. Ceramic nozzles and porous-cooled blading were referred to during the 1953 Conference on Steam Turbine Research and Development (Brown, 1953, Figs. 101, 102 and 103).

* Research Director, the Parsons and Marine Engineering Turbine Research and Development Association (Pametrada).

It should be noted that fewer strategic materials will be required in the hot gas turbine with liquid cooling than in the uncooled turbine operating at 1200 deg. Fah. In fact, indications are that a stainless ferritic material for the rotors will be entirely satisfactory, thereby obviating the troubles which occur with use of austenitic materials owing to the higher coefficient of expansion and the lower heat conductivity of the latter type of alloy. The high-pressure and intermediate-pressure turbines may have the general construction shown in Fig. 17, since it will be an

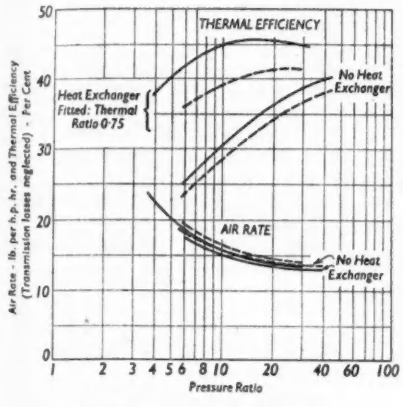

THERMAL EFFICIENCY
Heat Exchanger Fitted: Thermal Ratio 0·75
No Heat Exchanger
AIR RATE
No Heat Exchanger
Air Rate - lb. per h.p. hr. and Thermal Efficiency (Transmission losses neglected) - Per Cent
Pressure Ratio
Turbine inlet temperature, 2200 deg. Fah.
Cooling losses neglected.
Cooling losses allowed for.

Fig. 16—Variation of Gas Turbine Efficiency and Air Rate with Pressure Ratio

advantage to have them joined axially, leaving the low-pressure turbine coupled to the low-pressure compressor as a supercharger forming a separate sub-assembly. At the inlet end of the turbine, ceramic or effusion-cooled nozzles will be fitted. Some ceramic lining will be required, with effusion cooling fitted at the high-temperature gland and part of the ducting.

Heat Exchanger.—The heat exchangers so far fitted to industrial and marine gas turbines have been of the tubular type. The thermal ratio has been limited by considerations of size and weight to values usually in the region of 70–80 per cent (except in closed-cycle plants, where smaller tube diameters are permissible and higher thermal ratios are economically possible).

A considerable saving in weight and space could undoubtedly be made by adopting designs having secondary heat transfer surfaces, but to be fully effective the extended surfaces would have to be formed on both the gas and air sides. Such designs involve more complicated and expensive methods of production than the simple tubular type, and might, moreover, be more difficult to keep clean, so that the danger of corrosion and burning due to deposits on the surfaces might arise.

An alternative arrangement which has received attention recently (London and Kays, 1951) makes use of separate gas and air heat exchangers with liquid metal coupling. The separate exchangers would probably be of the cross-flow type with the liquid metal flowing through the tubes in a number of passes so as to approximate to contra-flow. The principal advantage of this scheme is that since the thermal resistance in both heat exchangers is almost entirely on the outside of the tubes a considerable saving in weight and volume can be made by using simple gilled tubes. Compared with a direct gas and air heat exchanger having plain tubes, the liquid metal coupled heat exchangers with gilled tubes show a saving in total weight and space occupied of the order of 50 per cent for the same thermal ratio.

A further advantage of this scheme, important in some applications, is that the arrangement of ducting can often be simplified, the individual gas and air heat exchangers being positioned to best advantage and connected only by the relatively small pipes conveying the liquid metal. It may, however, be some time before shipowners are convinced that pumps and joints for liquid metal meet the marine requirements of reliability.

The regenerative type of heat exchanger also offers the possibility of reduced size and weight as compared with the tubular type. In the regenerative type, heat is transferred from the hot gas to the air via a matrix consisting of a large number of fine elements which is exposed alternately to the hot and cold streams. An additional source of loss thus arises in this instance owing to the loss of high-pressure air to the gas side, due partly to the carry-over of air contained in the matrix voids, and partly to the leakage of air past the seals separating the air and gas compartments. One effect of this leakage loss is to give rise to an optimum thermal ratio. As the thermal ratio is increased the efficiency of the gas turbine cycle first increases to a maximum and then decreases again as the leakage loss becomes predominant.

Cox and Stevens (1950) have shown that for a gas turbine cycle with a pressure ratio of 4·35 and a maximum temperature of 1202 deg. Fah., and with seal leakage at the practicable value of 0·05 lb per second per foot length of seal, the optimum thermal ratio is 87 per cent, the leakage then being 5 per cent. For a high-temperature, high-pressure ratio cycle, in which the adverse effects of pressure loss and leakage are less, the optimum thermal ratio may be somewhat higher than this.

TABLE IX—*Counterflow Heat Exchanger Sizes*
(Thermal ratio, 75 per cent; ¼in Outside Diameter of Tubes)

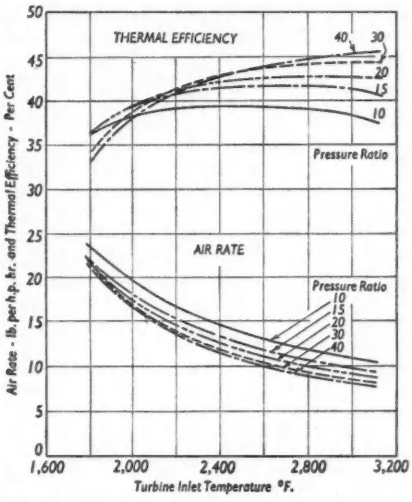
	Low-temperature cycle; maximum temperature, 1200 deg. Fah.; pressure ratio, 6		High-temperature cycle; maximum temperature, 2200 deg Fah.; pressure ratio, 20
Heat exchanger pressure loss, per cent	2	4	12
Reduction in thermal efficiency, per cent*	2½	4½	4½
Tube length, feet	16	17	27
Number of tubes†	3200	2300	230
Tube plate area, square feet†	7·5	5·4	0·78

* Reduction in thermal efficiency as compared with the same thermal ratio and zero heat exchanger pressure loss. It is expressed as a percentage of the thermal efficiency with no pressure loss.
† Per 1000 s.h.p.

As regards mechanical reliability of the regenerative type of heat exchanger, Cox and Stevens (1950) have reported much progress. It would appear, however, that thermal distortion can be accommodated more readily in a small exchanger than in a large one.

Fortunately, the ordinary tubular heat exchanger can be used for the high-temperature, high-pressure gas turbine. High-pressure losses can be allowed in the cycle with little loss in efficiency. This fact, coupled with the reduced air rate, leads to a great reduction in heat exchanger size, as is shown in Table IX.

Summary of Deductions on the Hot Gas Turbine.—The best fuel consumption which



Thermal ratio of heat exchanger, 0·75; cooling losses allowed for.

Fig. 18—Variation of Gas Turbine Efficiency and Air Rate with Turbine Inlet Temperature at Various Pressure Ratios

can be seen within the scope of this survey of hot gas turbines is 0·33 lb per s.h.p. per hour for all propulsion purposes. This is a possible improvement of 35 per cent over the best fuel rate for steam turbines at the present conditions of 640 lb per square inch gauge, 850 deg. Fah., as against 24 per cent for the 1500 lb per square inch gauge, 1500 deg. Fah., with two reheat points. This is a considerably greater improvement than that possible within the present-known limits of a steam cycle. The grounds for a cautious optimism about the use of residual fuel in gas turbines have already been stated. Improvements in bearings, gearing, manœuvring, control gear, &c., very briefly referred to in the section on future steam turbines, would also apply here. Even with the present multi-stage type of construction which would be required for high thermal efficiency a very great reduction in steaming weight would automatically follow from the figures for air rate. In the main propulsion machinery alone a weight reduction factor of 3 or more could easily be obtained, although the complete machinery

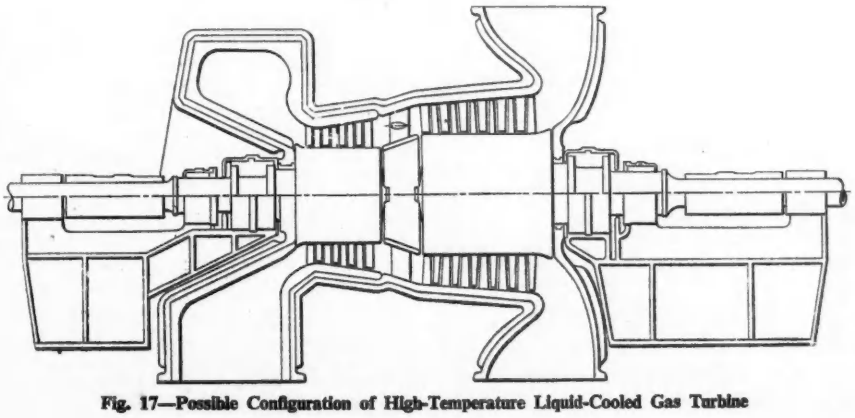


Fig. 17—Possible Configuration of High-Temperature Liquid-Cooled Gas Turbine

installation would not be reduced by this amount since such items as shafting, propellers, ladders and gratings, bilge and ballast pipes, &c., would be relatively unchanged.

Conclusion

The effect of T_1, the highest temperature in the cycle, on steam and gas turbines has now been examined as far beyond present practice as possible while still utilising known materials. The survey shows that, for marine use, steam turbines have still a long way to go before they reach their probable limit. It is also hoped that, throughout the lecture, the close interaction and relation between the steam turbine and the gas turbine, particularly in the high-temperature field, have been demonstrated. It is clear that the high-temperature gas turbine will be a lighter installation possessing higher thermal efficiences than are possible in steam plant. The fundamental difference, as regards the temperature aspect, between steam cycles (or for that matter the closed-cycle gas turbine) and cycles for open-cycle gas turbines is one of heat transfer through the superheater tubes as against the direct generation of heat in the working fluid. The pipes, nozzles and blades can be cooled in a steam cycle, but there does not seem to be any way of surmounting the problem of transmitting heat of the highest temperature and pressure which the superheater (or the air heater in a closed-cycle gas turbine) can stand. This sets a natural limit to the temperature of the steam cycle, which does not apply with the open-cycle gas turbine. The economics of the changes suggested have not been examined. The way will be hard, but there are no grounds for pessimism. It may be objected that the use of strategic materials required for high-temperature turbines, both steam and gas, will rule them out. It must, however, be remembered that even in a high-temperature nstallation the portion of the superheaters piping, and the hot part of the high-pressure turbine involved is about 2 per cent of the total weight, "steam up." On the other hand, surely oil (on which nearly all ship propulsion depends) is among the most important of strategic materials.

In the projected use of nuclear power the heat produced by the pile will require conversion to mechanical work by means of either steam or gas turbines, and no essential change in the type of construction other than what is needed for protection against radiation will be involved. Already there are doubts, however, about the availability of uranium in relation to the power generation requirements of the future.

There is no apparent reason to suppose that steam or gas turbines will be superseded as prime movers. These changes in temperature to achieve higher thermal efficiency will become imperative, since, during its effective life, a ship will consume oil representing, say, 25,000 per cent of the machinery weight. It is left to others to decide whether this attempt to survey the field of high-temperature turbine propulsion has been sufficiently convincing. Of the necessity for the survey there can be no doubt.

Monel Metal Ragbolts.—Some notes have been issued by Henry Wiggin and Co., Ltd., on the satisfactory results obtained with the Lewis ragbolts made of Monel which were used to secure the flap valves to the granite faced river wall on the site of the South Bank Exhibition. The valves are fixed by means of ¾in diameter ragbolts made from 1¼in diameter Monel bars. A recent inspection revealed that no corrosion of the bolts has taken place during the four years they have been in service. It is pointed out that although the first cost of Monel bolts was about double that of ordinary steel bolts they prove economic in the long run owing to their much longer working life. The fact that these bolts last much longer is particularly important in that the replacement cost of a ragbolt is generally much higher than the original cost of the bolt.

Stresses in a Crane Jib*

The purpose of the tests here described was to measure the stresses at selected points in the jib of a 10-ton electric derrick crane under working conditions with the ultimate aim of comparing these stresses with the allowable design values. Electrical resistance strain gauges were used for stress measurements under both static and dynamic loading conditions.

THE jib of the crane tested was 120ft long and designed for a working load of 10 tons at 90ft radius. A drawing of the crane is reproduced in Fig. 1 upon the plate facing page 218 of this issue. The following test sequence was agreed with Mr. J. H. Huntley and Mr. J. Patrick, of Butters Brothers and Co., Ltd., makers of the crane:—

Static Tests.—

	Crane hook load	Jib radius
1	15 tons	28ft
2	10 tons	90ft
3	15 tons	90ft
4	10 tons	110ft

Dynamic Tests.—(1) Jib radius 90ft, 5 tons lowered on fast gear and braked, repeat with 10 tons on slow gear; (2) jib radius 28ft, 10 tons lowered in slow gear and braked; (3) 10 tons load derricked from a jib radius of 28ft to 90ft and braked; (4) 10 tons slewed at a jib radius of 90ft and braked; (5) 10 tons slewed at a jib radius of 110ft and braked.

For the static loading tests axial stresses were measured at twenty-four points in the main angles and twenty-eight points in the latticing at each of two sections, 32ft and 61ft 4½in respectively up from the jib bottom pin. The layout of these gauges is given in Fig. 10. In the dynamic loading tests stresses were recorded at sixteen points in the main angles at a section 9ft up from the jib bottom pin. The dynamic stresses at four points only could be recorded simultaneously and consequently each dynamic test sequence was repeated four times to give complete readings for the section. It was agreed that the test results were to be presented in terms of total stress values—inclusive of dead load effects—so as to be directly comparable with calculated values supplied by Butters Brothers and Co., Ltd.

Static Tests: Test Procedure

1. *Effects Due to Load on Hook.*—To assess these effects the jib was set at the required radius and the gauges set to zero with no load on the crane hook. The test load was then lifted, gauge readings taken, followed by release of the load and a check on the zero gauge readings. The stresses corresponding to these gauge readings are due to the crane hook load only and are referred to in the article as "load" stresses.

2. *Dead Load Effects.*—Dead load stresses due to the weight of the jib were obtained as follows:—

(*a*) With no load on the crane hook the jib was laid out flat, the jib point being supported by means of wooden blocks on the same level as the jib bottom pin. With the derrick rope slackened the gauges were zeroed in this position. The derrick rope was then drawn taut until it just lifted the jib point clear of the supporting blocks and gauge readings were then taken in this position. Finally, the jib point was replaced on the blocks, the derrick rope slackened and the gauge zeroes checked. The stresses corresponding to these readings give the effects of the derrick rope pull on the jib due to its own weight. Knowing these stresses for the horizontal jib position the corresponding stresses for any jib and derrick rope inclination can be calculated.

(*b*) To obtain the bending stresses due to the jib weight only, the jib was laid out flat and supported as in paragraph 2 (*a*) with the derrick rope removed. The gauges were zeroed in this position. The jib bottom pin was then drawn, the jib turned right over sideways through 180 deg. and the pin reinserted so as to give the initial support conditions. Gauge readings were taken in this position, the stresses corresponding to these being twice the actual stresses due to bending of the jib under its own weight and over its full length. Checks on zero readings were again taken by turning the jib back into its original position. The stresses obtained from the readings in tests 2 (*a*) and 2 (*b*) are referred to in the article as "dead load" stresses.

Static Test Results

3. *Total Stress Values.*—In converting strain gauge readings to stresses a Young's Modulus value of 13,400 tons per square inch was used as obtained from test pieces. The total stress values were taken as the algebraic sum of the following "load" and "dead load" stresses. The "load" stresses were given directly by the readings for the hook load tests as described in paragraph 1. The "dead load" stresses (due to jib weight only) for the various jib radii consist of:

(*a*) Direct and bending stresses due to derrick rope pull were proportioned from the results of the derrick rope dead load tests described in paragraph 2 (*a*), allowing for the inclinations of jib and derrick rope for any given jib radius.

(*b*) Bending stresses due to jib weight were proportioned from the results of the jib weight dead load test described in paragraph 2 (*b*), according to the ratio (actual radius in feet)/120ft.

(*c*) Direct stresses due to jib weight are due to the axial component of the jib weight when the jib is inclined. They could not be measured directly and were calculated for the main angles using the formula:

$$f = Wh/120A$$

where f is the required stress, A is the area of the cross section considered, W is the weight of the jib portion between the section considered and the jib point, and h is the height of the jib point above the jib bottom pin in feet.

4. *Recorded Stress Values in Latticing.*—These were generally small and near the limit of sensitivity of the strain gauges of about 0·30 ton per square inch. The maximum stress values were obtained with a crane hook load of 15 tons at 28ft radius and the corresponding total stresses are shown in Table I. The accuracy of the measured stress values generally is ±5 per cent.

5. *Comparison of Experimental and Calculated Values of Total Stresses and Average Flange Loads.*—To allow an overall comparison to be made between the test results

* Based upon a Report prepared for the Association of Crane Makers on the results of tests carried out on the jib of a 10-ton electric derrick crane. The work was undertaken by the Department of Civil and Mechanical Engineering of the Royal Technical College, Glasgow, on behalf of the Association of Crane Makers, through the agency of Mr. J. H. Huntley of Sir William Arrol and Co., Ltd. The testing was carried out at Sir William Arrol's Crane Works, Parkhead, Glasgow.

and the standard methods of calculation the experimental and calculated total stress values for the main angles are presented in Figs. 2 to 9 (see plate, page 218). In these figures an additional comparison is made on the basis of the respective loads on the top and bottom flanges due to the various actions itemised in paragraph 3. The top flange area is taken as the sum of the areas of the two top angles and similarly for the

TABLE I.—*Stress Values in Lattice Bars*

Gauge Group	1	2	3	4	5	6
1	−0·45	−0·10	−0·14	−0·74	None	
2	−1·04	−1·03	Inoperative	−1·15	None	
3	−0·19	−0·16	−0·29	−0·37	None	
4	−0·20	−0·40	−0·11	+0·46	None	
5	−0·27	Inoperative	−0·17	0	−0·57	−0·29
6	−0·24	−0·67	−0·94	−0·74	Inoperative	−0·53
7	+1·03	+0·27	+0·44	+0·48	None	
8	−0·75	−0·46	−0·55	−0·37	None	
9	+0·62	−0·40	+0·85	+0·12	None	
10	+0·03	+0·23	+0·56	−0·05	None	
11	+0·16	+0·01	+0·55	+0·35	−0·13	−0·17
12	−0·68	+0·36	+0·29	+0·52	+0·31	+0·67

Crane hook load = 15 tons. Radius to load = 28ft
Direct stress due to jib weight negligible.
All stress values in tons per square inch.
Tension shown as +
Compression shown as −
For gauge positions refer to Fig. 3.

bottom flange. The flange load in any given case is the product of the flange area and the relevant average stress on the flange.

The methods used in arriving at these loads are given in a sample set of detailed calculations in the Appendix. Referring briefly to the experimental values given in the tables of Figs. 2 to 9, the total flange load P_1 was obtained from the total stresses given on the figures. The direct load P_2 was based on the sum of the stresses obtained as in paragraphs 3 (*a*) and 3 (*c*) above. The bending load P_3 due to jib weight was based on the stresses described in paragraph 3 (*b*). The flange load due to thrust eccentricity P_4 was then computed as $P_4 = P_1 - P_2 - P_3$. The total axial load taken by the latticing was negligible.

6. *Discussion of Results.*—(*a*) As already stated, the general accuracy of static stress measurements by electrical resistance strain gauges has been found to be about ±5 per cent. A rough check on this accuracy is provided by the experimental values given in Figs. 2 to 9, of the total direct load on the jib at the test sections. These values are summarised in Table II. For a given test the total direct load at the lower jib section

TABLE II.—*Total Direct Load at Test Section*

Crane hook load (tons)	Jib radius (feet)	Recorded (tons)		Calculated (tons)*
		Section 32ft from jib bottom pin	Section 61ft 4½in from jib bottom pin	
10	110	29·0	29·6	33·0
15	90	47·7	43·6	46·5
10	90	35·3	30·4	33·5
15	28	45·3	43·2	44·0

* Based on conventional design method, assuming half of jib weight to be concentrated at the jib point: this method disregards the variation of the direct thrust along the jib, due to its own weight.

should equal that at the higher jib section plus the normal component of the weight of the jib between the two sections. In all cases the percentage variation in the measured total direct loads is within ±5 per cent of the mean value for the two sections, allowing for the intervening jib weight.

(*b*) The total flange load values (Figs. 2 to 9) show reasonable agreement for the direct and bending effects due to thrust on the jib. The calculated values of the flange loads equivalent to bending effects due to jib weight are for the larger jib radii higher than the experimentally recorded magnitudes. The deviation is about 18 per cent at its maximum. It should be noted, however, that while the measured total loads carried by top and bottom flanges correspond to the calculated values the division of these loads between individual angles shows in practically every case a definite lack of symmetry in loading. This is shown clearly in Fig. 11—see plate—in which the measured loads on the individual main angles are tabulated. Viewing the jib sections from the jib bottom it is seen that the left-hand top and bottom angles tend to take a greater share of the jib thrust than the corresponding angles on the right-hand side. This feature is indicative of some thrust eccentricity laterally—that is, in the direction *XX* as shown on the key diagram on Fig. 11. Such lateral eccentricity is additional to the known eccentricity of thrust in the direction *YY* due to the vertically offset load line. The effect is particularly pronounced for the section 32ft from the jib bottom pin. The loads carried by the latticing did not conform to any regular pattern and were probably influenced by the accidental eccentricities and distortions undergone during fabrication.

(*c*) The standard method of stress calculation assumes that at a given cross section of the jib the plane of loading is in the central *YY* axis and that the section acts under bending as an integral unit. The recorded stress values show, however, that these assumptions are not necessarily correct. The mean stresses for each angle indicate, as noted in paragraph 6 (*b*), that, at the lower test sections in particular, the plane of loading has been offset from the central *YY* axis, giving rise to moments (and stresses) at 90 deg. to the primary bending actions. A more complex condition is the apparent irregularity of the local stress variation over individual main angles. In several cases greater stress values were recorded at the inner points of the main top angles than at the top edge of the angles where maximum stress is supposed to exist. There is, in fact, clear indication that each main angle acts to some extent independently under its own share of the load, and, in addition, there is evidence of local bending actions being superimposed on the main direct and bending stresses.

The effect of these secondary actions on maximum stress is shown in Table III.

TABLE III.—*Comparison of Recorded and Calculated Maximum Stress Values*

Crane hook load (tons)	Jib radius (feet)	Section 32ft from jib bottom pin		Section 61ft 4½in from jib bottom pin	
		Calculated stress (tons per square inch)	Recorded stress (tons per square inch)	Calculated stress (tons per square inch)	Recorded stress (tons per square inch)
10	110	4·70	5·34	4·05	3·99
15	90	4·64	5·62	4·15	4·28
10	90	4·03	5·62	3·61	3·63
15	28	4·19	5·10	4·68	5·00

It should be noted that the recorded maximum stresses quoted do not always occur at the position indicated by the calculations. The recorded maximum stresses for the section near the jib centre are generally in agreement with the calculated values. The lower jib section, however, shows recorded maximum stresses up to 40 per cent in excess of the calculated values, due primarily to the lateral eccentricity of the jib thrust at this section. It should also be noted that total stresses are higher at this lower section than at the centre. This is in agreement with the calculated results.

STATIC TESTS: SUMMARY AND CONCLUSIONS

7. (*a*) The division of the jib thrust between the top and bottom flanges is given correctly by the standard method of calculation, good agreement with the experimentally recorded values being obtained.

(*b*) An examination of the experimentally recorded flange loads carried by each main angle indicates lateral eccentricity of the jib thrust particularly at the section 32ft from the jib bottom pin. This effect is regarded as peculiar to the particular jib tested.

(*c*) The greatest stress values and flange loads were recorded at the section 32ft from the jib bottom pin. The absolute maximum stress value recorded at this section was 5·62 tons per square inch, corresponding to a crane hook load of 15 tons at 90ft jib radius.

(*d*) The stress variations recorded in the tests indicate that the jib sections do not behave integrally as assumed in calculations, but that each component angle acts to some unknown extent independently under its own share of the load. Such non-integral behaviour is regarded as a basic characteristic of built-up members and requires further investigation. Since the effect is to increase local stresses it is suggested that it would be well worth while to carry out a test to failure on a built-up jib.

DYNAMIC TESTS: TEST PROCEDURE

Dynamic stresses were measured by a Kelvin and Hughes four-channel recorder and, as stated in the introduction, each test sequence was repeated four times to obtain records from the sixteen gauges used. All gauges were placed axially on the main angles in the positions indicated on the test records, Figs. 12 to 17. The jib section investigated, 9ft up from the jib bottom pin, was that at which maximum slewing stresses would occur.

8. *Static Load Effects.*—The static stresses at each gauge due to test load and dead load effects were first determined for each test load and jib position, using the static strain gauge equipment. The stresses due to test load thus measured were used in checking the calibration of the dynamic stress recording equipment, which, of course, also indicates static stresses when no dynamic effects are present.

9. *Load Drop Tests.*—The test load was lifted to a convenient height in the appropriate jib position. Attached to the underside of the test load was a string carrying two indicator weights at a fixed distance apart. The load was then lowered at the required speed, which was measured by noting the time interval between the first and second small weights hitting a platform on the ground. The brake was suddenly applied when the second indicator weight hit this platform. During this operation the stress variation was continuously recorded. In addition the travel of the load during braking was given by the length of string on the ground beyond the second weight. The deceleration of the load was estimated from this distance and the initial speed of the load.

10. *Luffing Tests.*—It was decided to measure the derricking distances by change in jib inclination rather than by distance travelled by the load, as the swing of the

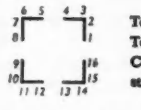
load introduced errors. An inclinometer preset to the difference in angular inclination between 90ft and 28ft jib radius was attached to the jib near the jib bottom so that it could be observed during the crane operation. The test load was then derricked from a stationary lifted position at 28ft radius until the inclinometer came to zero indicating the 90ft jib radius. The brake was then suddenly applied. The time taken for the jib to traverse the angular distance from 28ft to 16ft 10in diameter circle between the 90 deg. marking pole and the final position of the crane indicator was also noted. From these the slewing velocity and the jib point deceleration were estimated. Continuous stress records were again taken during the whole operation.

Test Results

12. The test results—as measured—are presented in Tables IV and V. Typical

TABLE IV.—*Experimentally Recorded Dynamic Stresses: Lowering and Luffing of Load*

Gauge positions
View from jib bottom pin



Test section 9ft from jib bottom pin.
Tension shown +
Compression −
static stresses quoted do not include dead load effects.

Gauge No.	5 tons lowered at a jib radius of 90ft				10 tons lowered at a jib radius of 90ft				10 tons lowered at a jib radius of 28ft				10 tons luffed from a jib radius of 28 to 90ft			
	Load velocity, ft/sec	Load deceleration, ft/sec²	Static stress, ton/in²	Dynamic stress, ton/in²	Load velocity, ft/sec	Load deceleration, ft/sec²	Static stress, ton/in²	Dynamic stress, ton/in²	Load velocity, ft/sec	Load deceleration, ft/sec²	Static stress, ton/in²	Dynamic stress, ton/in²	Jib point velocity, ft/sec	Jib point deceleration, ft/sec²	Static stress, ton/in²	Dynamic stress, ton/in²
1	2·15	2·74	−0·30	−0·37 +0·37	0·83	0·40	−0·85	−0·15 +0·3	0·83	0·92	−1·03	0 +0·22	2·04	4·80	−0·85	0 +0·45
2	2·15	2·74	−0·12	−0·45 +0·37	0·83	0·40	−0·79	−0·23 +0·3	0·83	0·92	−0·73	0 +0·3	2·04	4·80	−0·79	0 +0·45
3	2·15	2·74	−0·18	— —	0·83	0·40	−0·97	— —	0·83	0·92	−0·42	— —	2·04	4·80	−0·97	— —
4	2·15	2·74	−0·36	−0·37 +0·42	0·83	0·40	−1·33	0 +0·45	0·83	0·92	−0·91	0 +0·15	2·04	4·80	−1·33	−0·07 +0·23
5	2·22	5·06	−0·85	−0·6 +0·6	0·85	0·48	−1·51	−0·3 +0·6	0·84	0·47	−1·45	−0·12 +0·12	2·04	4·80	−1·51	−0·38 0
6	2·22	5·06	−1·03	−0·6 +0·6	0·85	0·48	−1·70	0 0	0·84	0·47	−1·69	0 0	2·04	4·80	−1·70	— —
7	2·22	5·06	−0·85	−0·3 +0·6	0·85	0·48	−1·63	−0·15 +0·15	0·84	0·47	−1·69	−0·12 +0·12	2·04	4·80	−1·63	−0·38 0
8	2·22	5·06	−0·97	−0·3 +0·6	0·85	0·48	−1·69	−0·2 +0·2	0·84	0·47	−1·75	0 +0·15	2·04	4·80	−1·69	−0·30 0
9	2·20	3·50	−1·03	−0·3 +0·45	0·85	0·62	−2·78	0 +0·3	0·84	0·47	−2·60	−0·3 +0·15	1·92	1·80	−2·78	−0·30 0
10	2·20	3·50	−1·57	−0·45 +0·3	0·85	0·62	−3·02	−0·15 +0·15	0·84	0·47	−3·02	−0·15 +0·15	1·92	1·80	−3·02	−0·30 0
11	2·20	3·50	—	— —	0·85	0·62	—	— —	0·84	0·47	—	— —	1·92	1·80	—	— —
12	2·20	3·50	−0·79	−0·45 +0·15	0·85	0·62	−2·42	0 +0·15	0·84	0·47	−2·41	−0·15 +0·15	1·92	1·80	−2·42	−0·30 +0·15
13	2·13	5·56	−1·33	−0·22 +0·37	0·83	0·72	−2·30	−0·15 +0·15	0·83	0·79	−2·24	−0·15 +0·15	2·04	3·6	−2·30	−0·30 0
14	2·13	5·56	−0·60	−0·6 +0·07	0·83	0·72	−2·42	−0·15 +0·15	0·83	0·79	−1·81	−0·15 +0·15	2·04	3·6	−2·42	−0·15 0
15	2·13	5·56	—	— —	0·83	0·72	—	— —	0·83	0·79	—	— —	2·04	3·6	—	— —
16	2·13	5·56	−0·42	−0·4 +0·2	0·83	0·72	−1·75	−0·2 +0·2	0·83	0·79	−1·51	−0·15 +0·15	2·04	3·6	−1·75	−0·15 +0·15

90ft radius together with the angle of jib travel beyond the 90ft radius position were noted. These gave the derricking speed and deceleration on braking. A continuous record of the stress variations at the section investigated was again obtained.

11. *Slewing Tests.*—The jib was slewed into a starting position at a slewing angle of 90 deg. from the braking position. These were marked out by means of surveying poles round the circumference of a circle of 16ft 10in radius. A pole was also attached radially to the base of the crane cabin and served as a crane position indicator relative to the poles fixed in the ground. After slewing was started the time taken to cover the central 45 deg. slewing angle was measured. When the crane had slewed through the complete 90 deg. the brake was suddenly applied. Once the crane came to rest the distance along the circumference of the stress records are shown in Figs. 12 to 17. In the records the "zero" line corresponds to no load on the crane hook with the jib at the appropriate radius. The dynamic stresses in Tables IV and V have been taken from the records and the values given are the maximum and minimum values respectively measured from the static stress line as datum. It should also be noted that the static stresses in Tables IV and V are those due to test load only, and do not include dead load effects.

It will be noted that the velocity and deceleration values—where such values were not governed by the gearing of the crane—vary somewhat for each repetition of a given loading sequence. This repetition of loading—as already mentioned—was necessary since only four gauge records could be handled simultaneously by the recording equipment. The variations in the velocity and deceleration values are due mainly to split second differences in the application of the brake. For purposes of comparison in Table V the equivalent dynamic stresses in the slewing tests are given for a jib point deceleration of 2ft per second per second.

As anticipated, the dynamic stress values obtained for all but the slewing tests are negligible at the section metered. This is because only in slewing do the maximum actions obtain near the foot of the jib. In all other cases they are more likely to occur near the centre of the jib. For this reason only the slewing results are presented in detail. Further, tests will be required to locate and evaluate the maximum stresses in the jibs due to these actions.

13. Slewing test results standardised to a jib point deceleration of 2ft per second per second for a crane hook load of 10 tons at 90ft and 110ft jib radii respectively are shown in Figs. 18 and 19. The stresses quoted were obtained by combining the dynamic stresses (obtained from records such as Figs. 16 and 17), standardised to a jib point deceleration of 2ft per second per second, with the measured static and estimated dead load stresses.

14. *Discussion of Results.*—(*a*) At the section 9ft from the jib bottom pin the dynamic effects of actions other than slewing are negligible. The results of the slewing tests

show some very considerable stress values. The maximum momentary total stress obtained is 12·50 tons per square inch compression at the heel of the top right-hand angle in Fig. 18, i.e. at No. 2 gauge position. This total stress is built up from a dead load stress of 2·21 tons per square inch, a test load static stress of 0·79 ton per square inch plus a dynamic stress at a jib point deceleration of 2ft per second per second, of 9·50 tons per square inch. This may be compared with the corresponding total static stress at the same position of 3 tons per square inch. The actions involved in producing the dynamic slewing stresses are complex and are not easily analysed. The total effective inertia force, for example, depends at the instant of braking on the relative positions of load and jib point. This, in turn, is governed by the length of lift rope between load and jib point. Added to this is the difficulty that as the load swings the direction of its inertia force exerted on the jib changes and with it the plane of the applied bending moment introducing unsymmetrical bending. The stress values shown in Figs. 18 and 19 are not simultaneous for the four angles and thus no comparisons of overall stressing actions can be made.

One striking feature is the influence of crane handling. Comparing the slewing deceleration values for 10 tons at 90ft and 110ft jib radius it is seen that the values for the latter are appreciably lower due to the driver instinctively handling the crane more carefully at the greater radius. This is conspicuously reflected in the stress values (Figs. 18 and 19), where, for the more severe condition of 10 tons at 110ft jib radius, the maximum total stress recorded of 8·39 tons per square inch compression is only about 67 per cent of the maximum stress—12·50 tons per square inch—for 10 tons at 90ft jib radius.

(*b*) The standard stress allowance for slewing corresponding to inertia of the jib weight only would appear to be wholly inadequate. At the same time, in view of the absolute dependence of the maximum stress values on crane handling it is difficult to see what allowance would be adequate. Further tests are necessary before a recommendation on this aspect could be put forward. The design factors for the slip clutch in the slew gear also require further consideration.

TABLE V.—*Experimentally Recorded Dynamic Stresses : Slewing of Load*

Gauge positions View from jib bottom pin

Test section 9ft from jib bottom pin.
Tension shown +
Compression −
Static stresses quoted do not include dead load effects.

Gauge No.	10 tons slewed at a jib radius of 90ft through 90 deg.					10 tons slewed at a jib radius of 110ft through 90 deg.				
	Jib point		Stress, ton/in²			Jib point		Stress, ton/in²		
	Velocity, ft/sec	Deceleration, ft/sec²	Static	Dynamic	Dynamic at 2ft/sec²	Velocity, ft/sec	Deceleration, ft/sec²	Static	Dynamic	Dynamic at 2ft/sec²
1	8·6	1·37	−0·85	−4·40	−6·34	10·5	1·13	−0·73	−3·00	−5·32
				+0·80	+1·15				+0·80	+1·42
2	8·6	1·37	−0·79	−6·60	−9·50	10·5	1·13	−0·60	−3·00	−5·32
				+2·40	+3·45				+0·80	+1·42
3	8·6	1·37	−0·97	—	—	10·5	1·13	−0·60	—	—
				—	—				—	—
4	8·6	1·37	−1·33	−3·50	−5·04	10·5	1·13	−1·15	−2·20	−3·89
				+1·12	+1·61				+0·40	+0·71
5	10·5	1·67	−1·51	−0	−0	10·5	1·41	−1·51	−0·90	−1·28
				+1·20	+1·44				+2·70	+3·83
6	10·5	1·67	−1·70	−0	−0	10·5	1·41	−1·57	−0·90	−1·28
				+0·30	+0·36				+3·00	+4·26
7	10·5	1·67	−1·63	−0	−0	10·5	1·41	−1·57	−0	−0
				+1·50	+1·80				+3·00	+4·26
8	10·5	1·67	−1·69	−0	−0	10·5	1·41	−1·63	−0·90	−1·28
				+1·05	+1·26				+2·70	+3·83
9	10·5	2·21	−2·78	−2·50	−2·27	10·8	1·33	−1·84	−0·60	−0·90
				+4·75	+4·31				+5·40	+8·13
10	10·5	2·21	−3·02	−2·15	−1·95	10·8	1·33	−3·27	−1·00	−1·51
				+5·00	+4·54				+2·80	+4·21
11	10·5	2·21	—	—	—	10·8	1·33	—	—	—
				—	—				—	—
12	10·5	2·21	−2·42	−2·15	−1·95	10·8	1·33	−2·50	−0·90	−1·36
				+4·30	+3·90				+3·60	+5·42
13	9·8	2·66	−2·30	−3·60	−2·71	10·5	1·26	−2·36	−0·37	−0·59
				+0	+0				+0	+0
14	9·8	2·66	−2·42	−3·60	−2·71	10·5	1·26	−2·06	−0·37	−0·59
				+0	+0				+0·10	+0·16
15	9·8	2·66	—	—	—	10·5	1·26	—	—	—
				—	—				—	—
16	9·8	2·66	−1·75	−2·4	−1·81	10·5	1·26	−1·33	−0·10	−0·16
				+0	+0				+0·20	+0·32

DYNAMIC TESTS : SUMMARY AND CONCLUSIONS

15. (*a*) The dynamic stresses due to load dropping and derricking are negligible at a section 9ft from the jib bottom pin. Further tests would be required to determine the location and value of the maximum stresses due to these actions.

(*b*) The dynamic stresses due to slewing are greatest near the foot of the jib. During the tests carried out the maximum dynamic total stress obtained was 12·50 tons per square inch compression. This compares with a total static stress of 3·00 tons per square inch compression at the same point.

(*c*) The velocity values measured were, on the whole, constant as they are generally governed by crane gearing. The deceleration values, particularly in load dropping on fast gear and in slewing, show appreciable variation due to differences in brake application.

APPENDIX

CALCULATION OF STATIC FLANGE LOADS

The following sample calculations are given to illustrate the methods of obtaining the experimental and theoretical flange loads. They are for a load of 10 tons at 90ft radius and apply to the test section 61ft 4½in from the jib bottom pin.

P_1 = Load on flanges including all effects.
P_2 = Direct load on flanges including jib weight effect.
P_3 = Load on flanges due to bending action of jib weight only.
P_4 = Bending load on flanges due to eccentricity of thrust.

1. *Experimental Values.*—Refer to Fig. 5.

Average load on top left flange angle = $\frac{\text{Sum of gauge total stress values}}{\text{Number of gauges}}$ × (Flange angle area) = −10·4 tons

and similarly for the other flange angles.

Therefore P_1 for top flanges = sum of average loads on top flange angles = −(10·4+11·7) = −22·1 tons

P_1 for bottom flanges = sum of average loads on bottom flange angles = −(3·93+4·40) = −8·33 tons

Therefore total direct load on jib = −30·4 tons

Area of top flange angles 2×3·75 = 7·5in²
Area of bottom flange angles 2×2·86 = 5·72in²

Therefore total cross-sectional area = 13·22in²

Therefore P_2 for top flanges = −30·4×7·5/13·22 = −17·3 tons

P_2 for bottom flanges = −30·4 +17·3 = −13·1 tons

From Fig. 21.
Average bending stress :

Top flanges = Sum of (*A*) stresses/11 = −1·64 tons/in²

Bottom flanges = Sum of (*A*) stresses/12 = +2·35 tons/in²

Therefore

P_3 for top flanges = −1·64×7·5 = −12·3 tons

P_3 for bottom flanges = +2·35×5·72 = +13·4 tons

Since the top and bottom flange loads due to this bending action must be equal and opposite the value of P_3 may be modified as follows :—

P_3 for top flanges = −12·3+13·4/2 = −12·9 tons

P_3 for bottom flanges = +12·3+13·4/2 = +12·9 tons

$$P_4 = P_1 - P_2 - P_3$$

Therefore

P_4 for top flanges = −22·1+17·3 +12·9 = +8·1 tons

P_4 for bottom flanges = −8·33 +13·1−12·9 = −8·1 tons

2. *Calculated Values.*—Supplied by Butters Brothers and Co., Ltd.

From the force diagram in Fig. 20, thrust on jib = −33·5 tons.

(This assumes that half the jib weight acts at the jib point and jib bottom respectively.) Since the direct load is evenly distributed :

P_3 for top flanges $= -33 \cdot 5 \times 7 \cdot 5/13 \cdot 22 = -19 \cdot 0$ tons

P_2 for bottom flanges $= -33 \cdot 5 + 19 \cdot 0 = -14 \cdot 5$ tons

Weight of jib = 6·25 tons.

Bending moment at section under consideration due to this weight = 815 tons/in

Distance between centroids of top and bottom flanges = 51·6 inches

Therefore

P_3 for top flange $= -815/51 \cdot 6 = -15 \cdot 8$ tons

P_2 for bottom flange $= +15 \cdot 8$ tons

The line of action of direct thrust is 12·4in below the centroid of the section.

Therefore

Bending moment due to eccentricity of thrust $= 33 \cdot 5 \times 12 \cdot 4 = 416$ tons/in.

Therefore

P_4 for top flange $= +416/51 \cdot 6 = +8 \cdot 1$ tons.

P_4 for bottom flange $= -8 \cdot 1$ tons.

Motor Ships for the Clyde

By G. W. TRIPP, O.B.E., F.C.G.I., M.I.C.E.

The motor vessel "Arran" here described is one of three ships designed to carry 450 passengers, 20 cars and cargo on the Clyde. The method of handling cars from piers at all stages of the tide is of interest. The "Arran" has a length of 185·6ft, a breadth of 35ft and a draught of 7·6ft for a gross tonnage of 567·8.

FOR many years the Firth of Clyde was justly famous for its large fleet of fast passenger paddle steamers, a large proportion of which were owned by the three railways serving Glasgow, which vied with one another in seeking to have the fastest and most comfortable ships, competition being very keen. The advent of the turbine steamer threatened, but never supplanted the paddlers, as the former proved suited to the longer cruises rather than pier to pier work. To replace war losses, which were severe, only one new steamer was built, probably the best and most comfortable of the long line of distinguished paddle boats. The "Waverley" is illustrated (Fig. 1) for the sake of comparison with the ships in the new programme. Her principal dimensions are : length, 235ft ; breadth, 30ft ; depth, moulded, 8ft 9in ; tonnage, 639 gross. She is propelled by inclined triple-expansion engines with cylinders 24in, 39in and 62in diameter, and a stroke of 66in. For looks she would be hard to beat.

It came as a surprise when the Railway Executive announced that, with a view to economy, seven new motor ships were to be ordered, four being of relatively small dimensions specially suitable for maintaining the skeleton off-season services, as well as for short sea cruises. These were described in a previous article,* since when they have given a good account of themselves, although obviously they could not be expected by themselves to cope with the heavy seasonal traffic.

* THE ENGINEER, June 5, 1953

The three larger motor ships, the subject of this article, may really be classed as triple purpose, for they are designed to carry not only passengers, but cars, and cargo, while they have been constructed with a view to being capable of the quick turn-round essential to ships operating in connection with the tightly timed railway services from Glasgow and its suburbs. In addition to the cargo, excellent accommodation is provided for 450 passengers, and a crew of twenty, and for about twenty motor-cars.

The general appearance of these ships can be seen in the illustration of "Arran" (Fig. 2), the first to be put into commission ; the symmetry of her lines is somewhat spoiled by the gap in her side necessitated by the method of handling cars, to which allusion will be made later. She left the yard of her builders, William Denny and Brothers, Ltd., and successfully completed her trials in December, and went on service between Gourock and Dunoon on January 4th. She is of mild steel construction, has a raked stem, and cruiser stern, bilge keels amidships, and eight watertight bulkheads. Twin spade rudders are operated from the bridge with telemotor control. Her principal dimensions are as follows :—Length, 185·6ft overall ; 174ft between perpendiculars ; 180ft on water line ; breadth, moulded, 35ft; depth, 11ft 3in ; maximum draught, 7·6ft ; tonnage, 567·8 gross, 200·8 net.

The main propelling machinery consists of two sets of British Polar engines, each having six cylinders, with a bore of 340mm, and a stroke of 570mm, developing 1100 b.h.p. at a speed of 300 r.p.m. Silencers are located in the funnel. Power is transmitted to the twin screws, supplied by Bulls Metal and Marine Company, Yoker, by means of shafts supported in Cooper roller bearings, the diameter of the intermediate shaft being 6·5in and of the tail shaft 8·125in.

The cylinder jackets and covers of the engines are cooled by fresh water circulated in a closed circuit by means of an engine-driven pump, cross connections between the engines being fitted. Scavenge air is supplied by a double-acting reciprocating scavenge pump, direct-driven from the crankshaft ; each working cylinder has its own fuel pump, the fuel passing through a duplex filter before delivery to the pump. Oil for piston cooling and lubrication of the main engines is pumped through each system by two engine-driven pumps and a lubricating oil cooler and filter is fitted to each engine system. Fuel oil is supplied to the main engines and diesel generator engine gravity tanks by a motor-driven transfer pump made by Rotoplunge Pump Company, and by the oil purifier pumps.

The bilge and ballast and general service pumps take over the duties of the main engine pumps in an emergency, these pumps being supplied by Drysdale and Co., Ltd.

The manganese bronze propellers have a diameter of 6ft 6in, and a pitch of 6ft 7in. Her speed is 15·5 knots. During trials, when running at 304 r.p.m., a mean speed of 15·635 knots was attained, the total shaft horsepower being 1992. Two air compressors are driven by the main engines, each delivering 39·55 cubic feet of free air per minute at a pressure of 350 lb per square inch. There is also a spare Hamworthy electrically driven air compressor.

A hot water boiler plant supplied by Mackenzie and Moncur is fitted in the engine-room, and this supplies the necessary hot water for ship heating, wash-basins, &c. The exhaust silencers and spark arrestors for the main engines are of Vokes manufacture and the silencers for the generator engines are supplied by Burgess Products, Ltd. The engine-room has natural ventilating trunks from the funnel.

The general layout of the vessel is as follows. On the lower deck aft is the steering compartment with electric motor drive, a fresh water tank of 5 tons capacity and, for the diesel fuel oil, there are two tanks on the port and starboard sides of the engine-room, capable of containing 26 tons. Forward of the engine-room is a well-arranged smoke room and bar, the only passenger accommodation found on this deck. On the main deck aft are the crew's quarters, with comfortable two-berth cabins for sixteen seamen.

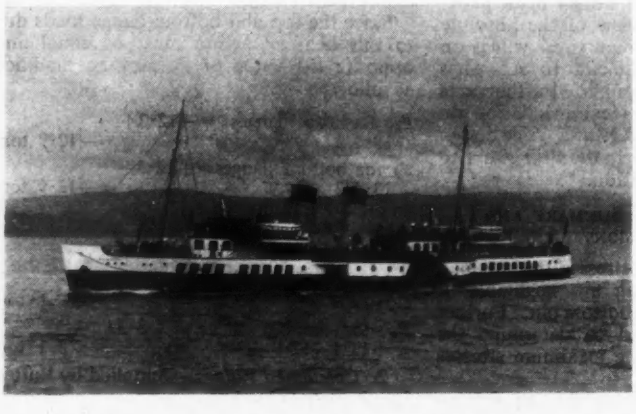


Fig. 1—The "Waverley," the Last Steamer Built for Clyde Services

Fig. 2—Motor Ship "Arran"

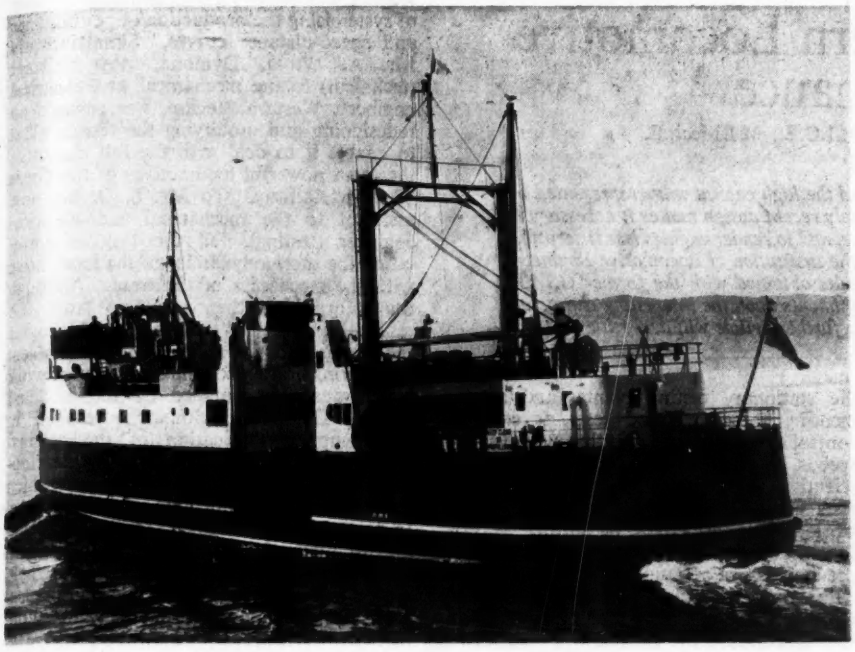


Fig. 3—Motor Ship "Arran," Showing Cargo Derrick and Gap for Car Platform

and their mess room, and forward of this is the cargo space. The cargo, arranged in containers, is drawn down to the quay side by small tractors, and lifted aboard by 2-ton derricks (Fig. 3), operated by electrically driven worm geared winches supplied by Clarke, Chapman and Co., Ltd. Further forward is the car lift platform, a special feature of this ship. This platform is raised and lowered by two winches supplied by Clarke, Chapman and Co. Ltd., driven by a 55 b.h.p. electric motor. The up and down travel of this lift allows for a difference in height of 15ft 6in, so that at all states of the tide the platform can be brought level with the quay. The car gangways, which form the side of the ship when at sea, are raised and lowered by four winches supplied by Thomas Reid and Sons, Ltd., each being driven by a 3 b.h.p. electric motor. The car lift cannot be put into motion until two gates, separating it from the cargo space on one side, and the car garage (Fig. 4), on the other side, are securely shut; in case of electric failure hand gear is also provided consisting of spur drive and crank handle; on the platform are two turntables to bring the cars into the most suitable position for driving into the garage which occupies the rest of the vessel, a turntable in the bows (Fig. 4) enabling a car to be driven down one side of the engine-room casing and then, having had its direction changed on the turntable, to be driven down the other side of the engine-room, enabling the first car on the ship to be the first to land; forward is also a small capstan to be used if necessary in the shifting of cargo containers. On the main deck astern there are comfortable quarters for the engineers and chief steward, forward of which is the cargo hatch, then the space for the car lift, followed by the main passenger entrance and ticket office; next on the port side is a comfortable combined dining room and tea toom, seating thirty-eight people at six tables for six and one for two, while on the corresponding starboard side is the toilet accommodation, and towards the bows and the full width of the vessel a spacious and comfortable lounge seating 131 passengers, the seats being arranged transversely. Finally, on the promenade deck, are situated the cabins of the master, mate and purser, as well as buoyant seats for passengers, and two lifeboats, each arranged to carry thirty people.

Fig. 4—Car Deck, Looking Aft, Showing Turntable Installed to Facilitate Stowage

For berthing purposes on the upper deck forward there is an electrically driven mooring and anchor windlass, and astern a capstan, both of which as well as the small capstan on the main deck, were supplied by Thomas Reid, of Paisley.

The vessel is lighted throughout by electricity, for the provision of which as well as for the various motors about the ship there are three diesel generators, supplied by Russell Newbery and Co., Ltd., each of a capacity of 60kW at 220V d.c.

The names of the other two ships which are being built at the yard of the Ailsa Shipbuilding Company, Ltd., at Troon, are "Bute" and "Cowal," recalling the A.B.C. steamers of earlier days when the "Isle of Arran," "Isle of Bute" and "Isle of Cumbrae," of the Buchanan fleet, were so known, and perhaps "Arran," "Bute" and "Cowal" may go down to history as the later A.B.C. ships. The present intention is to use them on the three main shuttle services in connection with the railways: Gourock–Dunoon, Wemyss Bay–Rothesay, and Fairlie–Brodick (Arran). It might be of interest to mention that the charges for conveying cars between Gourock and Dunoon are, for those up to 12 h.p., 15s. single, and 22s. 6d. return, and for large cars, 20s. and 30s., respectively, charges which compare very favourably with those for a similar distance between the mainland and the Isle of Wight.

While these new motorships can hardly claim good looks, particularly when compared with their beautiful predecessors, they certainly promise to be efficient and economical on the work for which they are designed, perhaps particularly in the off-season when there are not so many passengers. A careful inspection of "Arran" gave the impression of much forethought, especially bearing in mind the necessity for rapid turn-round at the piers. The passenger accommodation is well laid out and comfortable, and they may be regarded as ships suitable for all weathers. Two minor drawbacks were noted: first, that passengers can only be landed and embarked at one point so that a degree of trouble may arise in the busy season, and, secondly, that the lift opening precludes passengers from the use of the after end of the vessels, but it is admitted that this cannot be helped. It would appear that a line of demarcation is now being drawn between the essentially business vessels and those used for cruising, for which the existing turbine and paddle steamers are so eminently suited. Certainly the new ships seem to be an excellent compromise between the somewhat exacting requirements of the present day travelling public and the necessity for the provision of other facilities in the same ship.

The author's thanks are due to Mr. L. E. Marr, manager of Clyde Shipping Services, and to British Railways for all the facilities so readily afforded in the collection of material for this article.

FILM CATALOGUE.—We have received from the Owen Organisation, Kent House, Market Place, Oxford Circus, London, W.1, a film catalogue which gives details of the films produced for member companies of the group consisting of about forty engineering firms. The films cover such subjects as the manufacture of parts for the motor industry, agricultural equipment, mechanical handling appliances and the story of the B.R.M. racing car.

Improving Modern Locomotive Performance

By O. S. NOCK, B.Sc., M.I.C.E., M.I.Mech.E.

No. I

The long life of good British locomotives, and the high capital value represented by many hundreds of existing engines of relatively recent design makes it necessary to do all that is possible to improve performance, and to render engines less susceptible to inferior fuel. In a notable paper before the Institution of Locomotive Engineers Mr. S. O. Ell reveals some recent test results obtained with the former G.W.R. "King" class. In this article the author comments upon the interesting characteristic relations discussed in the paper, while a further article will deal with the work of the improved engines on the road.

THE performance of a locomotive, whether steam, electric, diesel-electric, or gas turbine, is inseparably bound up with the mechanics of a train in motion. No matter how efficient any form of motive power may be when working under ideal conditions the yardstick of efficiency—using the word efficiency in its broadest sense—must be the manner in which a service train is operated. For many years development of the steam locomotive continued in this country with very little in the way of precise data of performance to guide those responsible for design. The inherent flexibility of the steam locomotive and the way its overall efficiency is maintained over a relatively wide range of loading—both contributed to this unscientific process of evolution. But the time came when it was not possible to obtain more power merely by enlarging the previous proportions ; means of securing a higher power-weight ratio had to be found, and in more recent years the deterioration in the quality of coal available for the railways of this country has led many engineers to the belief that forms of motive power other than steam must be adopted on a large scale.

But in his Presidential Address to the Institution of Locomotive Engineers in September last Mr. R. C. Bond, analysing conditions on British Railways, showed clearly that while electrification was probably the eventual and logical outcome it would be a very long time before we could afford to dispense entirely with steam. Even on schedules particularly favourable to their use diesel-electric and gas turbine locomotives have so far shown no saving in fuel costs over well-designed steam units, and there is thus every reason for continuing development of existing locomotives both of the new standard types, and of the most efficient classes of the former independent companies. Difficulties have arisen in many ways since the end of the second world war. So far as coal is concerned it is often not so much the smaller sizes now so frequently supplied, even for crack workings, as the wide variation in quality and grade experienced from day to day. One day a top-link crew may receive first-class Welsh steam coal ; the next day they will have to run the same train with kitchen nuts ! To lessen the work of servicing locomotives at running sheds self-cleaning plates have been fitted, not only to the new standard designs but to older engines from which it is necessary to secure high monthly mileages. The insertion of these plates has, in certain cases, had an adverse effect upon the steaming. Thus, for various reasons it has been necessary to examine the performance of locomotives anew, and in this work the modern testing engineers have played, and are continuing to play, a very important part. The practice recently developed of conducting analytical tests at constant rates of evaporation on the stationary testing plants, and supplementing these by road tests at carefully controlled rates of evaporation with varying speeds, has produced the most accurate, scientific, and strictly comparable series of tests with locomotives ever yet seen in the world. The principles of testing as now followed have been described at length in previous issues of THE ENGINEER, and results with various types of locomotives fully discussed ; but in his recent paper before the Institution of Locomotive Engineers, Mr. S. O. Ell, of the Western Region Mechanical and Electrical Engineer's department, Swindon, has some very interesting passages dealing with the development of the system, and the actual details of tests that he uses to illustrate his paper provide further striking evidence of its success.

Present practice can be said to originate from a series of tests made on the Great Western Railway in the early 'thirties. An attempt was then being made to relate the timing of trains over various routes, under different loading conditions, to the most economical performance rates of the locomotive. Under the immediate direction of Mr. F. W. Hawksworth, who, as chief draughtsman, then had the work of the stationary testing plant and dynamometer car in his charge, the initial development work was carried out by various members of his staff. Among these, Mr. C. T. Roberts, now carriage and wagon engineer, Western Region, was achieving the substantial advance of systemising the production of performance and speed-distance curves. Simultaneously Mr. A. W. J. Dymond, now assistant (technical) to the mechanical and electrical engineer, Western Region, was engaged on redesigning and modifying the testing plant to enable it to deal with the full output of the most powerful locomotives of the Great Western Railway. To Mr. S. O. Ell, now assistant to the mechanical and electrical engineer (testing), fell the task of correlating the thermodynamics of the locomotive with the mechanics of the train. Although the information then available from test results was meagre enough, it did provide the premises for the approach to the problem and the inspiration for the development work which was then pursued on the modified plant. This work ultimately resulted in the complete vindication of the original approaches and directly led to the development of a locomotive testing technique which gives results of immediate practical value. In this work the engineers concerned, who are all men of the former Great Western Railway, have received the utmost help and encouragement from the mechanical and electrical engineer, Western Region, Mr. R. A. Smeddle, who in earlier years himself had an extensive experience of dynamometer car work on the former North Eastern Railway.

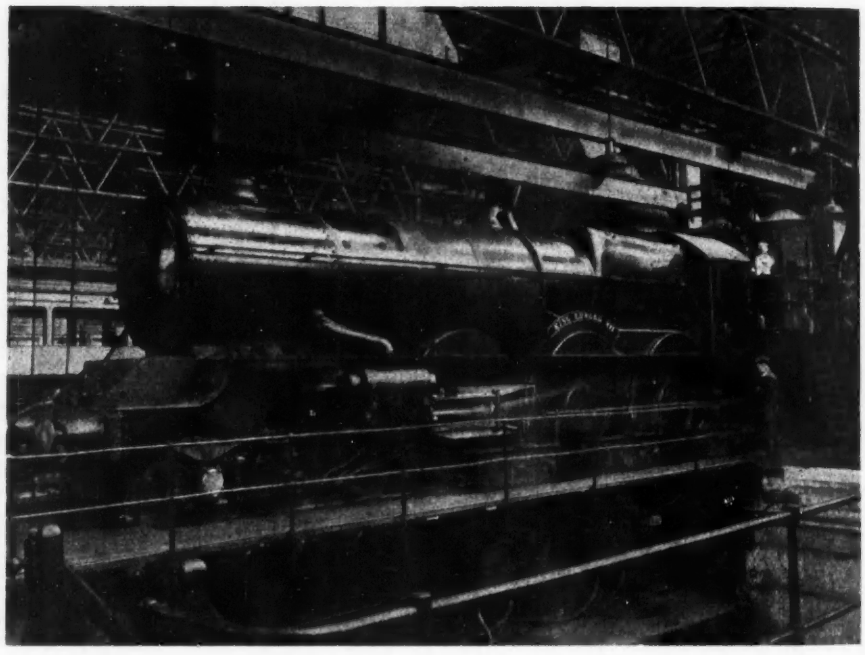


Fig. 1—No. 6001 "King Edward VII" at 75 m.p.h. Conditions on Swindon Test Plant

In the past thermodynamic analysis of locomotive performance has been confined to constant speed testing, largely because it was found difficult to contrive any other way. On the other hand, constant speed running is so totally different from anything a locomotive is required to do in actual service that it was felt that such results would not bear a true relation to the performance of a locomotive on a revenue-earning duty. Means had to be found of obtaining a truly accurate thermodynamic analysis without the artificiality of constant speed. The policy that was gradually evolved at Swindon was to base the assessment of locomotive performance and efficiency upon a three-fold relationship : (*a*) coal rate and steam rate ; (*b*) steam rate and power ; (*c*) power rate and coal rate. Having estab-

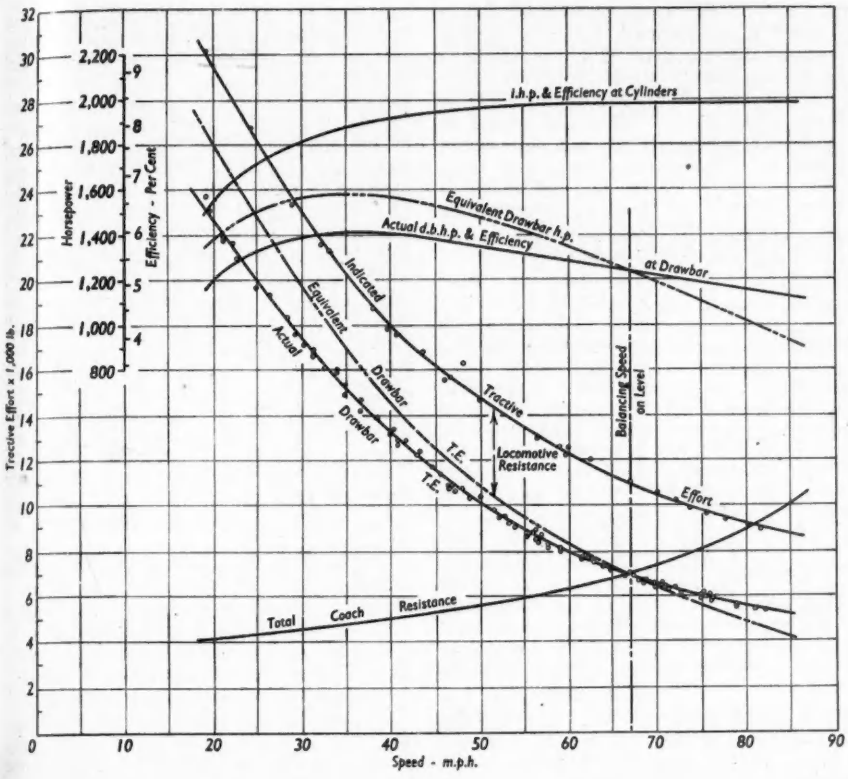


Fig. 2

lished these relations on the stationary plant at constant speeds, the means of applying such studies to a variable speed test was found by the introduction of a simple form of flow-rate indicator which enabled speed and cut-off to be adjusted in relation to one another while the steam rate remained constant. In due course it was demonstrated that there was no sensible difference in the results produced by the constant-speed and the variable-speed methods of testing. On each variable-speed test the principal boiler relations were unaffected by speed and the power-speed curve remained the same on all tests.

The controlled road test is of great importance for demonstration purposes in the manner in which the thermodynamic characteristics of the locomotive are linked to the practical job of hauling trains; but the stationary plant also has a further function to-day, apart from the task of establishing the characteristic curves of engine performance. It is the function of the test engineer of to-day to tune up the locomotive to modern requirements; to try the effect of new devices worked out in the drawing office, to make experimental modifications until an optimum performance is reached. In no respect has the work at Swindon recently been more successful than in the augmenting of steaming capacity. Reference has been made in previous articles in THE ENGINEER to the improvements wrought in the ex-L.M.S.R. class "2" and class "4" 2–6–0 mixed traffic engines; one of the late Sir Nigel Gresley's well-known "Green Arrow" 2–6–2 engines fitted with self-cleaning plates in the smokebox, was put through a full-dress series of tests, while the last class of locomotive on which trials have been completed is the G.W.R. "King." Some results from the last-mentioned tests are quoted in Mr. Ell's paper. Among locomotives designed and built prior to the second world war, the "King" must be considered one of the most successful. The designed power-weight ratio was high and the aim of the designer was achieved in service, with good fuel and a fine tradition of enginemanship. But while the post-war working of these engines has been generally good no task set to them has approached the maximum regular pre-war demands on the West of England service. To provide a greater margin of power in reserve for present running conditions or, to put it another way, to enable the performance of pre-war years to be repeated with the fuel of to-day, the draughting arrangements of the "King" class engines were examined on the stationary test plant, and a modified blast pipe evolved.

Mr. Ell's paper includes useful appendices covering the theoretical considerations on two aspects of draughting: first, as a yardstick of efficiency, and, secondly, showing that the discharge limit of the blast pipe orifice occurs when the velocity of the steam is equal to the velocity of sound in steam at the orifice conditions. In recent developments in front end design at Swindon it has been found that, in single blast pipe designs, the upper limit of the boiler is approached and sometimes fixed in good arrangements by the limiting discharge rate of the orifice. In the case of the "King" with the modified front end, which provides the example quoted throughout Mr. Ell's paper, the capacity of the locomotive is limited by the discharge rate of the orifice, and not by the draught. The boiler can steam continuously at rates in excess of 30,000 lb per hour without measurable quantities of carbon monoxide in the smokebox gas, when using Grades 1A and 2B coals. It is estimated that when self-cleaning smokebox plates are fitted the draught limit,

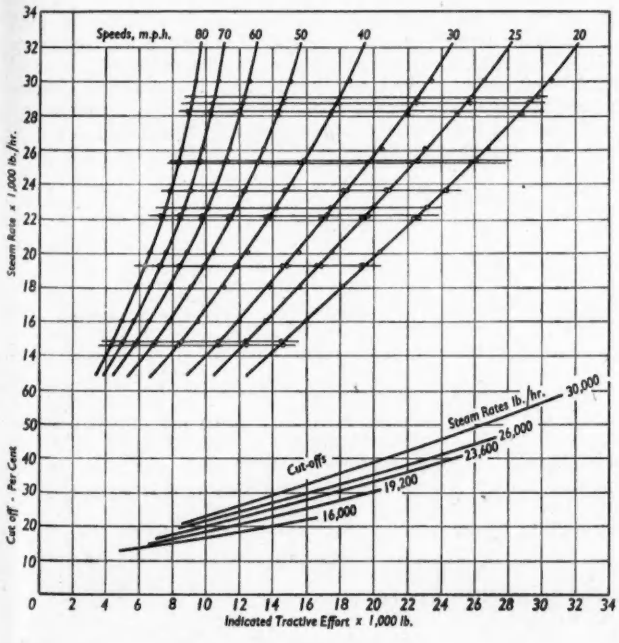


Fig. 3

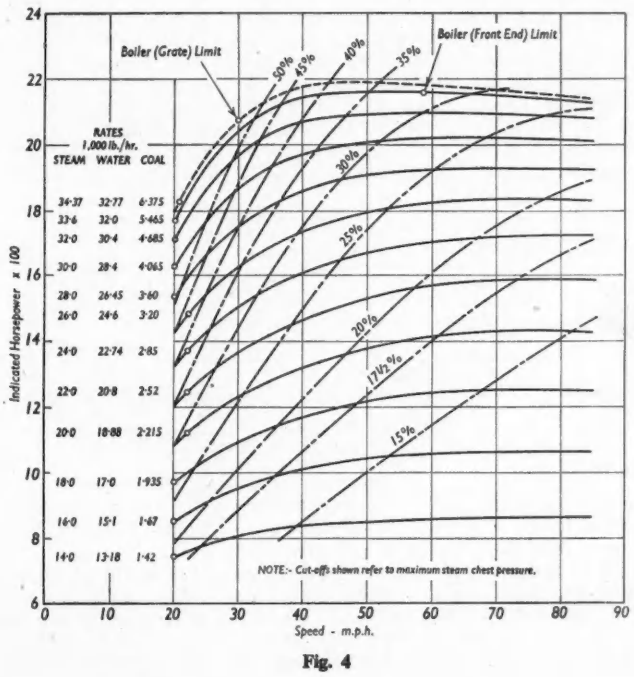

Boiler (Grate) Limit
Boiler (Front End) Limit
RATES 1,000 lb./hr.
STEAM WATER COAL
Indicated Horsepower x 100
NOTE:- Cut-offs shown refer to maximum steam chest pressure.
Speed - m.p.h.

Fig. 4

and the front end discharge limit, will approximately coincide. By the use of certain blast pipe and chimney proportions a limiting relation has been established between boiler size and orifice dimensions, and this has proved most valuable as a first approximation in design. This relation was actually applied in designing a new blast pipe that was fitted to two engines of the "King" class in the late autumn of 1952, several months prior to the "full-dress" trials on the Swindon testing plant. These engines so fitted won golden opinions from the operating staff in ordinary revenue-earning service. But at that time other commitments precluded the testing of one of the modified engines, and the final tuning-up, and establishment of the full performance characteristics was not accomplished until engine No. 6001 was put on to the stationary plant in the spring of 1953.

In finalising the dimensions two points have mainly to be borne in mind. If the engine steams too freely the discharge limit is below the draught limit and these should be made coincident by increasing the orifice diameter. If the steaming is unsatisfactory, it is unlikely that improvement would result from decreasing the orifice diameter; on the contrary, the resistance of the boiler should be investigated. In narrow firebox boilers the draught and discharge limits may approach and sometimes equal the grate limit. A good front end is a vital necessity. Many an otherwise good boiler has been condemned by its inferior front end. In many cases improvements may be carried out at extraordinarily little cost and can place the boiler limit of continuous evaporation more than 30 per cent higher than its normal working rate. This was actually done in the case of the "King." The combustion efficiency has been improved, but above all the higher maximum capacity is an insurance policy against those occasions when inferior fuel is provided. Whereas on the very heaviest duties in pre-war days the "King" class engines were required to steam continuously at rates of about 25,000 lb to 26,000 lb of steam per hour, for periods of about one hour on end, the modified and fully tuned-up engine No. 6001 has a front end limit of no less than 33,600 lb of steam per hour. What this means in actual haulage capacity was to a large extent shown on various controlled road tests, on one of which a load of twenty-three coaches weighing 781 tons behind the tender was run from Badminton to Steventon, 43·5 miles, at an average speed of 68·5 m.p.h. pass to pass. On this run, spectacular though it was, the steam rate was considerably below the maximum, namely, 28,700 lb per hour, though a continuous output of about 2000 i.h.p. was maintained.

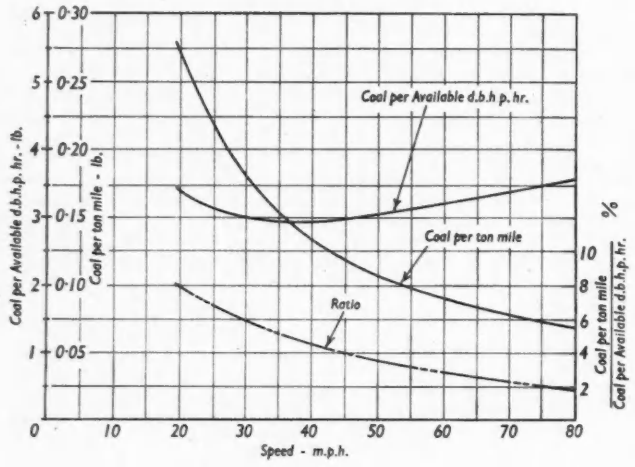


Fig. 5

Turning now from the actual improved performance obtained to a further examination of the methods of testing developed at Swindon, the effects of the very carefully controlled conditions on a road test are reflected in the consistency of the results obtained, despite the varying speeds. In Fig. 2 herewith is shown an analysis of the test previously referred to, between Stoke Gifford Sidings and Reading. During the time that the locomotive was "on load," at a constant rate of evaporation, the successive variations of speed were from 37 m.p.h. at the start to 47 m.p.h. sustained; then a steady acceleration running downhill to a maximum of 81 m.p.h., followed by maxima and minima of 57 m.p.h., 71 m.p.h., 70 m.p.h., 77 m.p.h., 15 m.p.h. (a permanent way check), and a final acceleration to 69 m.p.h. Referring to Fig. 2, on which the recorded points are plotted, it will be seen that there is remarkably little "scatter," and that the curves of indicated and actual drawbar tractive effort are defined beyond any doubt. The values of coal consumption and the efficiencies obtained are entirely realistic. The train has been run to a normal and representative schedule, with a natural load; if that load does happen to be considerably above anything that would be worked in ordinary service it is the natural corollary to a locomotive in first-class condition with Grade 1A coal. But in this variable speed test the thermodynamics of the locomotive were clearly and directly linked with the characteristic motion of the train.

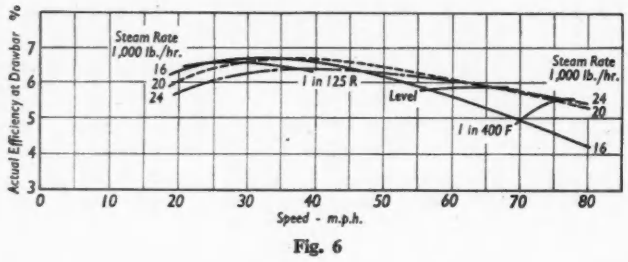


Fig. 6

A further interesting diagram is that shown in Fig. 3, where the values of indicated tractive effort are plotted on straight horizontal lines corresponding to the various steam rates at which tests were conducted, and then the points are joined up as well as possible by curves of speed. These curves are the lines representing the fundamental relation between the indicated steam rate and the hypothetical mean effective pressure for the condition of governing power output by cut-off—the Willans' lines. The actual points are plotted on this diagram and the measure of close agreement between results of the whole series of tests is remarkable. As Mr. Ell aptly remarks in his paper, such agreement "belies the opinions of some 'experts' that the indicated characteristics of the steam locomotive are so nebulous as to be practically indefinable." The diagrams reproduced in Figs. 2 and 3 represent the first stages in the co-ordination of the test results and up to this point not a single adjustment has been made or bias drawn. Fig. 4 shows the indicated horsepower characteristics of the improved "King" class engine, with a maximum front end limit of 33,600 lb of steam per hour and an indicated horsepower at 60 m.p.h. of 2150.

The Willans' lines corresponding to the drawbar tractive effort are also plotted on a diagram included in the paper. In these a wider scatter of the points is seen due to the varying wind effects upon the locomotive. During the complete series of tests the natural wind velocity varied between 7 m.p.h. against and in favour of the train. The speed lines on this diagram were given a bias towards the adverse, rather than the favourable conditions. The drawbar characteristics of a locomotive have an essentially practical use for train timing and the fixing of engine loads in relation to various schedules, and it is essential to give a conservative rather than an optimistic estimate of load hauling capacity. Having decided the appropriate allowances for the effect of a natural wind and established the drawbar characteristics of the locomotive it is interesting to study graphs such as those included in Fig. 5, which show the coal consumption for drawbar horsepower hour related to a particular test at a high steam rate. It will be seen that an economical rate of 3 lb to 3·5 lb per drawbar horsepower hour is maintained over the range of speed from 30 m.p.h. to 75 m.p.h. even though on this particular test the live steam injector was being used and the coal consumption increased by about 10 per cent in consequence. The curves of drawbar horsepower characteristics with the exhaust steam injector show a consumption of 2·75 lb per drawbar horsepower hour for a steam rate of 28,000 lb per hour at 60 m.p.h., while in normal express train working, as represented by use of 18 per cent cut-off at 65 m.p.h., the coal consumption read from the drawbar horsepower characteristics diagram is approximately 2·9 lb per drawbar horsepower hour.

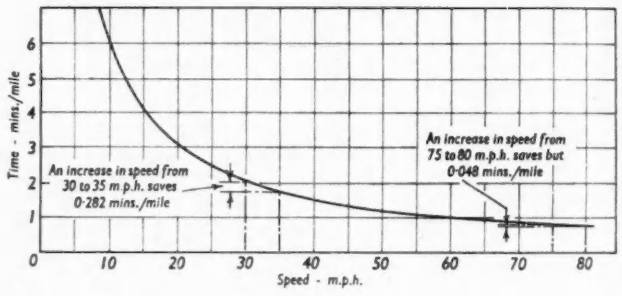

Time - mins./mile
An increase in speed from 30 to 35 m.p.h. saves 0·282 mins./mile
An increase in speed from 75 to 80 m.p.h. saves but 0·048 mins./mile
Speed - m.p.h.

Fig. 7

The manner in which analytical stationary tests and controlled road tests may be applied towards the most efficient use of locomotives

in service and the most economical timing of trains is well illustrated in Fig. 6. This relates to a service which with a load of 427 tons tare demands an average speed of 65 m.p.h. on the level. With an improved "King" class engine, this requires the production and utilisation of 20,000 lb of steam per hour. Working at this rate, speed on a long, adverse gradient of 1 in 125 would fall eventually to 30 m.p.h., and examination of the curves of efficiency at the drawbar for various rates of steaming might suggest that it would be more economical to lower the rate to 16,000 lb per hour. If this were done, however, the speed would fall to about 25 m.p.h. and the drop in speed actually results in a lower efficiency than that corresponding to a speed of 30 m.p.h. at 20,000 lb of steam per hour. The further diagram, Fig. 7, shows that a temporary increase in the steam rate from 20,000 lb to 24,000 lb is justified by the time saved in running—well over a quarter of a minute per mile, as the speed on the bank is raised from 30 m.p.h. to 35 m.p.h. On the other hand, no increase above the normal rate is justified in the high speed range ; the saving of time resulting from a considerable increase on the steam rate is relatively small, and is certainly not justified on the score of economy.

Among many recent observational runs made on the Western Region, one in September last, provided an excellent example of the way in which running times may be laid down, and accurately observed when such timings are based on steam rates maintained as uniform as possible. It requires good enginemanship to observe this uniformity, and it also goes almost without saying that good firing is essential on the sure basis of an optimum firebed. The particular runs in question were made on a two-hour non-stop timing between Paddington and Bristol, a round trip of 235 miles, with engine No. 6001. On the basis of data obtained during the analytical tests of this locomotive sectional timings had been laid down so as to maintain a relatively constant steam rate. On the actual run the passing times were observed with a most monotonous regularity, and the whole trip closely conformed to controlled road testing conditions. This logical outcome of locomotive testing has now developed to a stage where schedules can be produced rapidly and accurately for any route, taking account, of course, of any speed limits imposed due to curves, junctions and so on, and indeed this particular branch of the test engineer's work is becoming regarded as an exact science.

(To be continued)

Large Transonic Wind Tunnel

SITE work has now commenced on the large transonic wind tunnel at Bedford, which has been designed by the Aircraft Research Association. This association was formed by fourteen British aircraft companies in 1952 in order to build and run a tunnel of this size.

It will have a working section 9ft wide by 8ft high and will be able to test models of from 3ft to 5ft span up to a Mach number of 1·3. By using the latest developments in tunnel design tests will be made through the speed of sound and the characteristics of the aircraft will be examined in this speed range where most difficulties in control and stability are to be expected. The aim is to use the tunnel for development work on new designs by firms and so relieve some of the pressure on Government research establishments and enable them to devote more time to fundamental research. It is expected that the tunnel will be in operation in about two years' time.

It will be powered with electric motors and a total of some 35,000 h.p. will be required at full load, this being taken direct from the 132,000V grid system. Since the tunnel was required quickly, complication in the design has been avoided wherever this was possible. Provision has also been made on the site for a smaller tunnel capable of testing models at up to Mach 2·5.

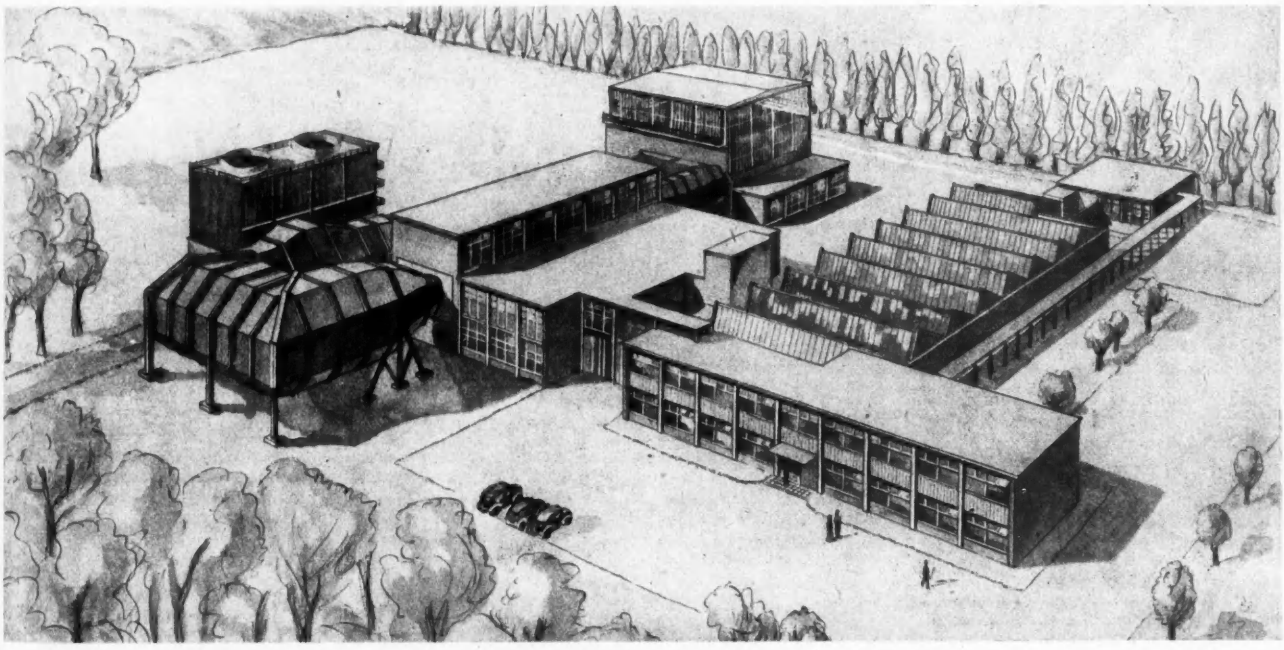
Tunnel Design.—The tunnel is of conventional design, using a closed circuit with a contraction ratio of 11 to 1 and diffuser angles of about 5½ deg. total cone angle. It is being constructed of welded steel and octagonal sections are being used over most parts of the circuit to simplify construction. A small pressure range of about 0·2 atmospheres above or below atmospheric pressure can be used to enable the Reynold's number, the load on the models and the power required, at a given Mach number, to be varied. The additional expense and complication of making the tunnel capable of operating over a wider pressure range was not thought to be justified.

The main fan drive for the tunnel consists of a two-stage fan of 21ft diameter with twenty blades to each stage. The blades will be made from laminated mahogany and bolted to a metal hub. Provision is being made for a static adjustment of the blade angles over a small range to enable the power required to be adjusted to suit the revolutions per minute of the driving motor. Flaps are also to be put on the pre-rotation vanes to control the amount of twist put in the air stream ahead of the fan. These flaps will be adjustable while the tunnel is running and will enable the power input and hence the tunnel speed to be altered over a small range without any change in the revolutions per minute of the fan.

The fan is being driven by a 25,000 h.p. slip-ring induction a.c. motor with a Ward Leonard controlled d.c. motor of 1500 h.p. coupled to it. Coarse control of tunnel speed is obtained by adjustment of a liquid resistance coupled to the rotor of the a.c. motor, but fine control is being obtained by using the Ward Leonard control on the d.c. motor. This method of composite drive is one which has been used with some success on American tunnels and makes it possible to hold the speed of the fan to within 0·1 per cent. The d.c. motor has a large torque at low speeds and will be used to start the fan, the a.c. motor being switched in when the fan has reached about 200 r.p.m. This avoids the large starting surge usual with an a.c. induction motor.

Provision is being made in the design for the addition of a further a.c. motor and two more stages on the fan if it is required to increase the power input in the tunnel.

In addition to this main power drive there is a twelve-stage axial compressor with a 10,000 h.p. motor. This will enable a smaller supersonic



Artist's Impression of Large Transonic Wind Tunnel

tunnel with a working section about 2½ft square to be run up to a Mach number of about 2·5 or slightly above.

Cooling and Drying.—Since the tunnel has a closed circuit, the heat equivalent to the power put into the tunnel has to be extracted from the air stream. This is being done by a large cooler in the air stream, 36ft wide by 30ft high, consisting of a number of banks of copper tubes and fins. Water is circulated through the copper tubes, so removing the heat from the air and keeping it at not more than 25 deg. Cent. above the outside air temperature. The water is cooled in a forced draught cooling tower, the maximum water circulation rate for the whole plant being about half a million gallons an hour. Some water is lost by evaporation in the cooling tower and this loss has to be made up. To avoid deposits on the inside of the cooler tubes this make-up water is being treated to remove the hardness salts. In addition to cooling the air the humidity in the air must be controlled at a low value, otherwise condensation shocks appear in the working section and disturb the flow. All the air entering the tunnel circuit must therefore pass through an alumina drier to remove most of the moisture. The aim is to run the tunnel with a moisture content of less than 0·001 of a pound of water per pound of air, i.e. about 10 per cent of the maximum summer humidity.

Model Testing.—Electrical resistance strain gauges will be used for measuring the forces on the models. It is planned to test both complete models and half models mounted on the floor of the tunnel. To enable these models to be changed quickly a system of model carriages has been designed, which can be wheeled into the tunnel with the model already mounted on its balance and supporting rig.

Since a large number of results can be obtained in a short time, plans are being made to provide as much automatic computation aid as possible so that the time taken to produce the correct results is reduced to the minimum.

Buildings.—In addition to the tunnel and its associated motor house, compressor house, observation room, &c., a workshop is being provided to enable some of the models to be constructed. These models will have to be made from solid light alloy or even in some cases steel. Methods of shortening the time of construction will have to be achieved if the tunnel is going to be successful in giving the designer the information required at an early enough stage. Various methods of model construction are therefore being investigated.

When it is finally completed the tunnel will employ a total staff of eighty to one hundred people. It will probably be run on a double-shift basis, enabling up to at least thirty models to be tested in a year.

The architects for the buildings are Ley Colbeck and Partners, of London; the main building contractors, Robert Douglas, Ltd., of Birmingham; the main electric power drive is being supplied by The English Electric Company, Ltd.; and the tunnel shell is being built by Moreland Hayne and Co., Ltd. of London, and G. A. Harvey and Co. (London) Ltd. of Greenwich.

Locomotives for the Spanish National Railways

IN May last, the North British Locomotive Company, Ltd., Glasgow, delivered the first of an order for twenty-five 2–8–2 tender locomotives for the Red Nacional de los Ferrocarriles Espanoles. The locomotives, which are for mixed traffic operation, have been built to the requirements of Senor Don Armando R. Flobert, of the Departmento de Material y Traccion and under the inspection of Livesey and Henderson. One hundred locomotives to the same design are being built in Spain and the bulk of the material for their manufacture is being supplied by North British Locomotive Company, Ltd.

The principal dimensions of the locomotives, one of which is illustrated on this page, are as follows :—

Cylinder, diameter × stroke	570mm × 710mm
Wheels, coupled, diameter	1560mm
Wheels, leading truck, diameter	860mm
Wheels, trailing truck, diameter	1080mm
Wheels, tender bogie, diameter	1080mm
Wheelbase, coupled	5124mm
Wheelbase, engine	10,830mm
Wheelbase, engine and tender	19,566mm
Heating surface, tubes (fire contact)	187 sq. m
Heating surface, firebox (fire contact), including arch tubes	20·5 sq m
Heating surface, total evaporative	207·5 sq m
Superheater (fire contact)	72·0 sq m
Total heating surface	279·5 sq m
Grate area	4·8 sq m
Working pressure	15 kg/sq cm
Tank capacity	27,000 litres
Coal capacity	11,400 kg.
Weight of engine in working order	101,555 kg
Weight of tender in working order	62,895 kg
Total weight of engine and tender in working order	164,450 kg
Tractive effort at 85 per cent working pressure	18,860 kg

The boiler barrel consists of three rings; its longitudinal seams are quadruple riveted with inside and outside butt strips and the circumferential seams double riveted. The distance between the tube plates is 5485mm and the smokebox tube plate is attached to the boiler barrel by a solid rolled angle ring and stayed above the tubes by braces to the first barrel ring. The outer firebox back plate is supported by flanged brace plates to the outer wrapper plate.

The firebox outside shell is of the round top radial stayed type fitted with direct steel roof stays. Four rows of sling stays are also fitted at the front of the box to allow for expansion. The brick arch is supported on four arch tubes of 76mm outside diameter. A thirty-four element "Melesco" superheater equipped with anti-vacuum valve is fitted and a "Joco" regulator in the dome is operated by a trigger control working in a quadrant. An "Equi" design firegrate is fitted, the drop grate being operated by hand and the rocking grate by means of an "Equi" steam cylinder.

The boiler is supported at the front and rear of the firebox by oil lubricated expansion shoes attached to the foundation ring, contact being maintained with bearing slides fixed to the frame cross stays by holding down clips. A cylindrical smokebox has a cast iron chimney and blast pipe with a "Kylala Kylchap" single exhaust system fitted with a basket spark arrester.

Main plate frames cut from rolled plate are finished to a thickness of 30mm. The front and hind dragboxes and cross stretchers are of flanged steel plates and angles, and a centre racking plate is provided. The smokebox saddles, slide bar brackets, reversing link trunnion brackets, stretcher at the front of the firebox and draw pin casting incorporated in the hind drag box, are steel castings. Platform plates of steel are supported by brackets, attached to the boiler, giving easy access to boiler and smokebox fittings, while carrying the larger pipes of the Worthington feed pump below the platform. Side buffers and draw hooks are fitted at the front of engine and the rear of tender. The connections between engine and tender consist of a ratchet adjustable drawbar, safety chains and spring-loaded buffers bearing on a facing strip on the engine hind buffer beam.

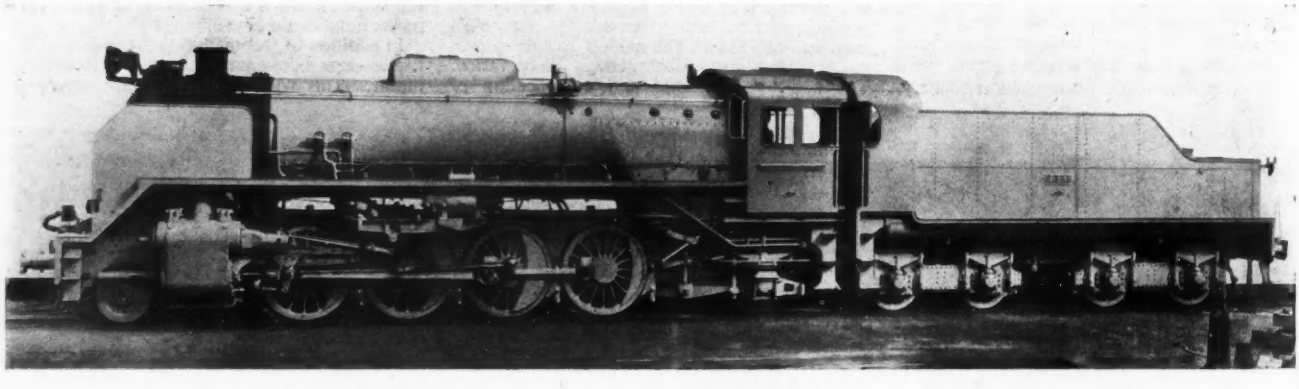
Overhung laminated bearing springs are fitted and spring compensation is arranged in two groups, between front truck, leading and intermediate wheels and driving, trailing and hind truck wheels. Lubrication of the coupled axleboxes is by means of one eight-feed "Silvertown" mechanical lubricator and the guides are lubricated from oil boxes situated on the frame. The whole of the revolving masses and 33⅓ per cent of the reciprocating masses are balanced.

A leading truck of swing link design is fitted with Skefko cannon roller bearing axleboxes, and the load is applied centrally from the compensating beam to the swing links through laminated bearing springs. A hind truck of the radial arm design has outside Skefko roller bearings and spring side control gear. The total side play of the leading and trailing trucks is 190mm and 140mm respectively, which permits the locomotives to negotiate curves of 175m radius.

Steam brake equipment is fitted on the engine and operates blocks on the rear of all coupled wheels. A counter-pressure brake valve is fitted and vacuum braking is provided for the tender and train. Efficient means of gravity sanding is provided at the front of the leading and trailing coupled wheels and the sand box is mounted on the boiler barrel adjacent to the dome with gearing operated by hand from the cab.

The tender is built to R.E.N.F.E. standard practice and is interchangeable with existing tenders. Its underframe is built up of longitudinal channels and is well stayed in all directions by cross channels, steel plates and sections.

Bogie frames built up from plate and channel have attachments for brake and spring gear and Skefko roller bearing axleboxes are fitted.



[Main Line Mixed Traffic Locomotive for Spain

Some Model Experiments on Special Control Valves

By D. FIRTH, A.M.I.Mech.E.,* and LESLIE YOUNG†

No. I

In this paper, presented before the Institution of Mechanical Engineers on January 29, 1954, a description is given of some model experiments undertaken to resolve problems occurring in the design of special control valves for use in the Hydraulic Machinery Laboratory of the Mechanical Engineering Research Laboratory. Four types are dealt with: (1) a valve to control flows varying from 1 to 30 cubic feet per second in a flow meter calibrating system; (2) a valve to control flows of up to 30 cubic feet per second in an open pump testing rig with a maximum input of 350 h.p.; (3) a valve to control flows varying from 1 to 20 cubic feet per second in a closed pump research rig with a maximum power input of 350 h.p.; and (4) a hydraulically-balanced in-line valve to control flows varying from 1 to 15 cubic feet per second in a service supply.

Design Requirements

A prime requirement for all the valves was that they should be free from fluctuations of flow or pressure in operation. The accuracy with which flow and pressure can be measured is often limited because of such effects produced by control valves. In addition, there were, of course, special conditions which had to be fulfilled by each type of valve. It was also necessary for the mechanical design of each valve to be such as to make remote control possible.

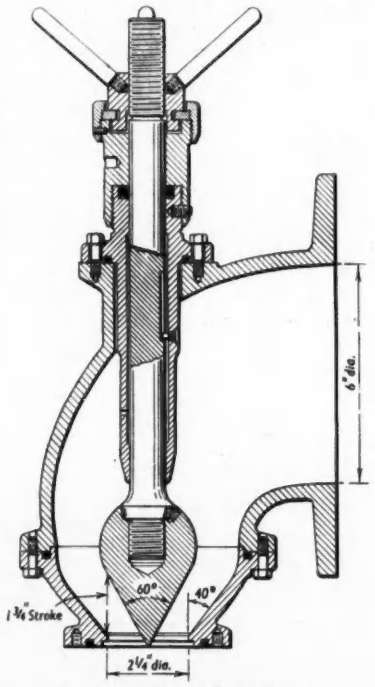
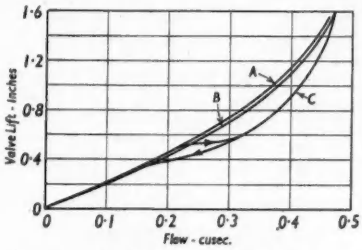


Fig. 1—First Model Valve Type 1

Valve Type 1.—Valve Type 1 has to control a flow varying from 1 to 30 cubic feet per second with a linear relation between flow and valve travel. It discharges to atmosphere under a constant head of 48ft of water, and must provide a clean and symmetrical jet at all flow rates.

Valve Type 2.—The limiting conditions of operation for valve Type 2 were specified as follows: maximum pressure drop required, 600ft of water; minimum pressure drop, 30ft; maximum flow, 30 cubic feet per second, minimum, 1; and the maximum power to be dissipated at any valve setting, 350 h.p. In addition, the discharge to a main sump had to avoid causing violent disturbance to the water surface or introducing substantial quantities of air.

Valve Type 3.—The requirements for the closed pump research rig were that a maximum of 350 h.p. should be dissipated with pressure drops varying from a maximum of 600ft of water, and flow rates of from 1 to 20 cubic feet per second. The pressure had to be broken down in such a way as to provide cavitation-free operation in the control valve over as wide a range as possible. A minimum pressure loss as small as was compatible with these aims had to be achieved. Consideration of the problem led to the adoption of a system of two valves in series as the most convenient way of meeting the specification.



Static head upstream of valve 89·5in.
A—Valve with vented fishtail.
B—Valve alone.
C—Valve with unvented fishtail.

Fig. 2—Relation Between Flow and Valve Travel

Valve Type 4.—Each valve of Type 4 had to be capable of controlling flows varying from 1 to 15 cubic feet per second with a maximum pressure drop of 120ft of water, and a minimum pressure loss as small as possible. [It was subsequently found that the range of speed control on laboratory service pumps could be made sufficient to meet varying demands without the use of control valves. That part of the paper relating to work done on this type of valve is therefore omitted.—Ed. The E.]

The Model Experiments

Valve Type 1.—A common arrangement for control in flow-measuring or calibrating systems is to use a gate or sluice valve at the end of a horizontal run of pipe, followed by a bend or elbow and a short vertical length of pipe through which the flow is discharged to a sump or measuring tank. In some instances the vertical pipe is swivelled to allow the flow to be diverted as required. The moment the outlet pipe is not running full, pressures below atmospheric are caused at the control orifice. The consequent flow of air up the pipe in the form of large bubbles causes fluctuation in the magnitude of this sub-atmospheric pressure. This fluctuation is conducted back up the line and causes pulsations in the flow indicating manometer. A further defect of this arrangement is that the characteristics of the gate valve are such as to make the fine adjustment of low flow rates a tedious operation. The remedies are: first, to ensure that the pressure at the control section of the system remains constant at all flow conditions, which may be done by discharging directly to atmosphere from the control orifice, and, secondly, to use a type of control valve having a linear relation between flow and travel under the conditions occurring in the system.

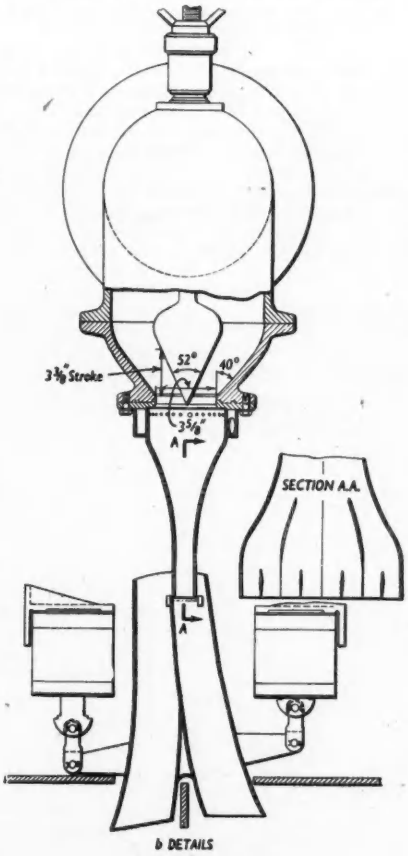


Fig. 3—Valve Type 1

An assessment of the specification for valve Type 1 led to the conclusion that the "spear" type of valve commonly used for Pelton wheel nozzles would be suitable. Because of space limitations, the entry to the valve had to take the form of a short-radius bend, and one problem was to decide if this would have any effect on the form or stability of the jet.

Two alternative designs were prepared for the elbow, one arranged to provide parallel flow and the other to provide contracting flow. The same spear and operating gear could be used in either. The design of the spear itself followed typical practice; an included angle of 30 deg. being used. A drawing of these components is given in Fig. 1. Models were made suitable for installation at the end of a pipe 6in in diameter, and were tested on a small calibration rig. Water was supplied from a constant-head tank at a pressure of 10ft of water, and the flow was measured by a Venturi meter installed twenty pipe diameters upstream of the valve. No difference in the performance of the valve with the parallel or with the contracting elbow was found, and the quality of the jet was equally good in both. Fig. 2 shows that the required linear relation between flow and valve travel was not attained over the full range of operation. It was found that splitters inserted in the elbow only increased the pressure loss through the valve, without producing any change in the shape of the characteristic or the quality of the jet.

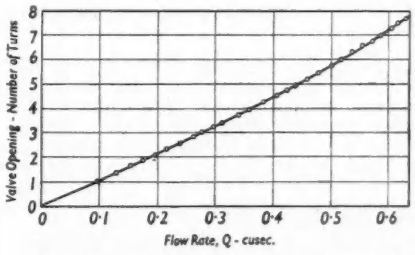


Fig. 4—Control Valve Calibration, Valve Type 1

These experiments were conducted with the valve discharging directly to atmosphere, and it was found that the pressure and flow in the pipe leading to the valve were exceptionally steady, in marked contrast to previous results when a gate valve had been used for flow control.

For accuracy in calibration of flow meters it was thought desirable to reduce to a minimum the time taken to divert the flow from the main sump to the measuring tank, and for this purpose it was necessary to produce a jet which was very narrow in the direction of diverter movement. A suitable nozzle had therefore to be found to convert the round jet obtained from the valve to the desired shape. A series of "fishtails" was designed and constructed to fit on to the valve, and a second set of experiments was conducted to investigate the performance of the combined arrangements. It was found that there was very little difference in the behaviour of the system whichever fishtail was used, so that the one which gave the narrowest jet in the direction of diversion was chosen for further development.

An undesirable effect caused by the addition of the fishtail was a region of instability of flow

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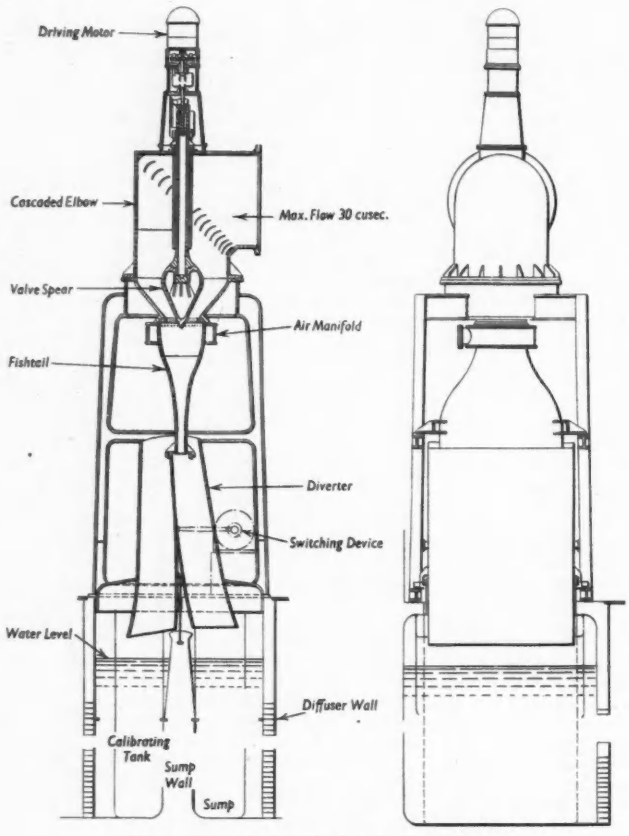


Fig. 5—Valve Type 1. Full-Scale Arrangement

at the point where the nozzle changed from running free to running full. As the valve was opened, a rapid increase in flow was obtained when the nozzle began to run full. Conversely, on closing the valve from the fully open position a rapid decrease in flow was observed at the point where the fishtail began to run free after running full. As the two flow changes did not occur at the same valve opening, a kind of hysteresis loop was obtained in the flow against travel characteristic, which is shown in Fig. 2. This effect was eliminated by providing an air vent just downstream of the control orifice of the valve through which a substantial quantity of air could be drawn. A characteristic was finally obtained for the combined valve and fishtail which differed very little from that of the valve alone, the difference being due to losses in the fishtail.

The provision of additional laboratory facilities enabled a larger model to be made to meet requirements for a calibrating system. This model was designed in the light of experience on the smaller model. Modifications were made to the shape of the spear in an attempt to obtain a linear characteristic, and to reduce its size. A companion fishtail was also designed from the results of the earlier experiments. This was provided with splitters to ensure good distribution of the flow across its width, and to give structural strength. An air vent was provided at the "neck" of the fishtail by a ring of holes leading to a manifold, which was connected to a vertical pipe of sufficient length to avoid flooding if the flow from the fishtail should be obstructed. To complete the unit, a diverter was designed which was operated by two solenoids. The diverter has a tongue which seals against the fishtail at the extreme ends of its travel —Fig. 3.

Tests showed that the valve and fishtail gave a linear flow against travel characteristic. The system was free from fluctuations of flow and pressure, and the operation of the diverter was satisfactory. The diversion cycle was examined by high-speed cinematography, and the time for complete operation was found to be $^1/_{25}$ second. Fig. 4 shows the control characteristic.

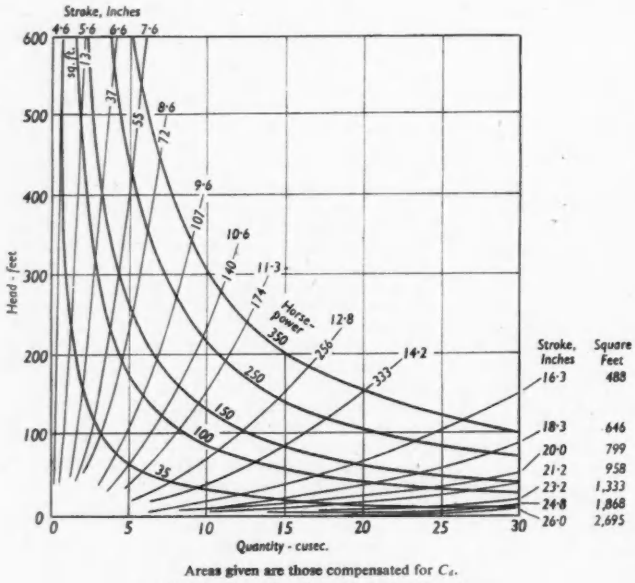
Specifications for the full-size design were prepared from the results of these experiments to meet the conditions given under Design Requirements. There were two departures from the two model designs. One was the use of a cascaded 90 deg. turn for the short-radius elbow at the valve entry. The other was in the method of operating the diverter. The use of solenoids was precluded because of the size of the unit, so the final choice was a d.c. motor giving 180 deg. movement as its normal operating characteristic. A proposed design drawing of the full-size layout is given in Fig. 5. As can be seen from this drawing, the valve drive is taken from a vertical electric motor operating the valve spindle through an epicyclic gear fitted with an automatic brake. Devices are included to limit the stroke, and to shut off the driving motor when a sufficient pressure for sealing is exerted on the valve seat. The entry to the valve is 30in in diameter, the control exit diameter is 14½in, the fishtail exit is 48in by 4½in, and the overall height of the unit is 19ft. The valve is to be fitted with a repeater motor which will indicate its position remotely.

The use of a cascaded elbow for the entry to the valve is perhaps worthy of mention. This device enables a right-angle turn to be made with very much less pressure loss than a sharp bend and gives a good velocity distribution, free from rotation at its outlet. They have been used with success at East Kilbride in various hydraulic circuits. Some experimental work on the use of turning vanes in water pipe elbows is described by Binnie (1950),‡ and their application to a specific hydraulic problem is dealt with by Rouse, Howe and Metzler (1951).

Valve Type 2.—The best solution to the problem of the design of valve Type 2 appeared to be to employ a form consisting essentially of a perforated cylinder submerged in the sump with its axis vertical, and having an internal sleeve, by the linear movement of which the number of perforations uncovered could be varied. By suitably grading the size of the perforations, any desired characteristic within fairly wide limits could be obtained.

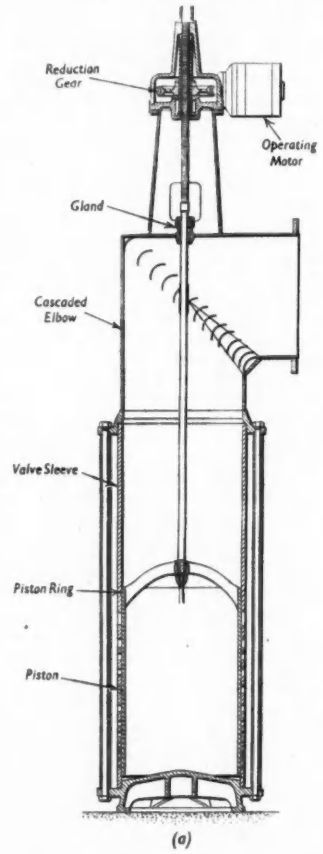
Designs using perforated cylinders 4in in diameter were prepared, and these models were constructed and tested at a valve manufacturer's works in Kilmarnock. They were submerged in a sump, the discharge from which passed through a stilling system over a triangular notch for flow measurement, and were supplied from a centrifugal pump giving a maximum head of 500ft of water.

The tests enabled the variation of the coefficient of discharge of the valve with the stroke to be established for various arrangements of perforations in the outer cylinder. Fig. 7*b* shows the characteristic obtained from the last of cylinders used. It is interesting to note that when the

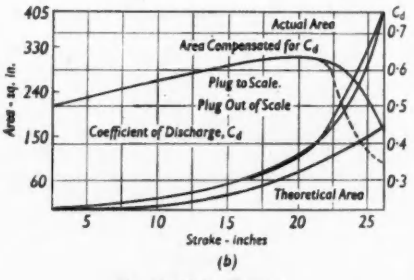


Areas given are those compensated for C_d.

Fig. 6—Duty Envelope for Valve Type 2



(*a*)



(*b*)

Fig. 7—Valve Type 2

‡ A list of references is given in Appendix II of the paper.

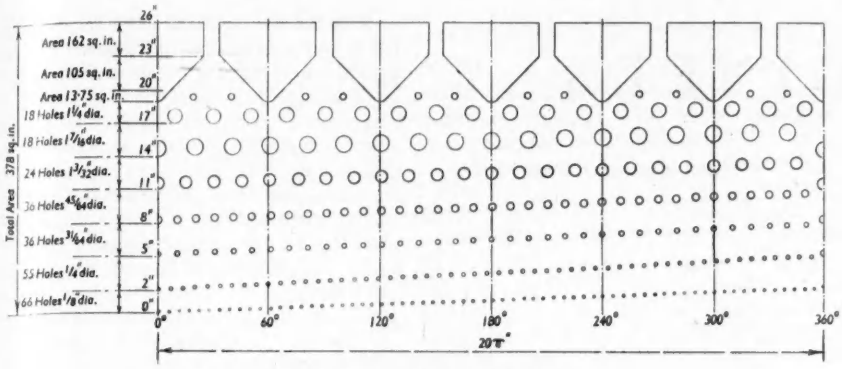


Fig. 8—Development of Valve Sleeve

valve was nearly open the internal flow area of the valve sleeve became a critical factor. The dotted line in Fig. 7*b* shows the relation obtained with a sleeve whose internal dimensions are not true to scale, while the full line gives the relation for a true-to-scale sleeve. The undesirable limit imposed in this way could have been eliminated by increasing the overall diameter of

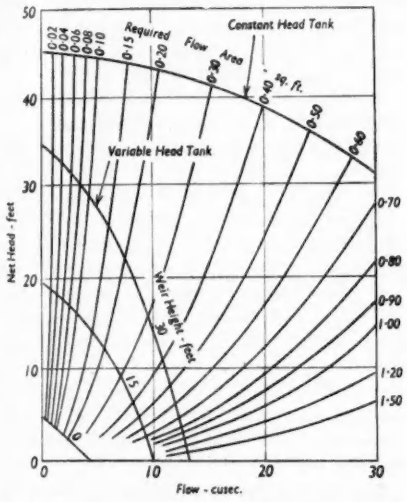
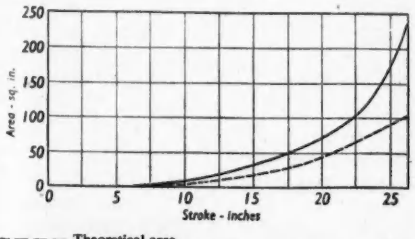


Fig. 9—Pressure Breakdown Valve Envelope of Duty

the valve, but this was not possible because of space limitations.

In Figs. 6 and 9 the duty envelopes for the valve on the pump testing circuit and on the overflow lines are shown. Superimposed on the curves are lines of constant valve orifice area compensated for the variation of coefficient of discharge with stroke. The lower of the curves on both drawings shows the theoretical areas exposed in the valve cylinder, and the upper curve shows the variation in area with stroke, compensated for the variation in coefficient of discharge.

The original aim was to obtain a linear variation of flow with valve travel as the limiting characteristic of operation, but consideration of the experimental results suggested that if this were done the valves would be working for most of their time over only a small part of their total travel. It was decided that a more efficient use of the control area available would be made if this area was allowed to vary as the cube of the sleeve travel. The curves shown in Figs. 7*b* and 10 are based on this relation. The way in which



Theoretical area.
Area compensated for C_d; actual area differs from this curve by less than 1 per cent.

Fig. 10—Design Data for Valve Type 2

more use is made of the available travel for the major part of the duty of the valves is shown in Figs. 9 and 10.

Because of the limit of 20in placed on the diameter of the full-size valve, the required variation of compensated area shown in Fig. 7 was not quite achieved. The piercing of the upper part of the cylinder must leave sufficient material for structural strength. This amount was reduced to a minimum in the design of the full-size valves by arranging that the external loads should be supported on a separate fabricated frame, as shown in Fig. 7*a*. This expedient enabled the outer cylinder to be pierced to the practical limit of machining possibilities. A development of the valve cylinder designed from the approximated curve of Fig. 7*b* is shown in Fig. 8.

One further result of the model tests must be mentioned. It was found that whilst the flow and pressure in the line leading to the valve were quite steady, the disturbance to the surface of the water in the sump was very great. This disturbance was eliminated by placing a screen of perforated metal extending for the full depth of the sump concentric with the valve cylinder. The screen had no measurable effect on the valve characteristic.

(To be continued)

Two-Channel Quick-Response Recorder

A TWO-CHANNEL quick-response pen recorder has been developed by Evershed and Vignoles, Ltd., Chiswick, London, W.4, and the instrument is shown in the accompanying illustration. It consists essentially of two recording voltmeters, each of which actuates a pen movement with a maximum torque of 7 ounce inches, both records being produced on a roll paper chart.

The recorder is servo-operated and works in conjunction with an amplifier, the two assemblies being connected by a 5ft length of eighteen-core flexible cable with plug and socket ends, as illustrated. The input to the recorder is opposed by the feedback voltage from a resetting potentiometer which is controlled by the position of the pen: the error, being the difference between these voltages, is amplified and drives the pen movement until the feedback voltage balances the input. The pen zero may be set in any position and a solenoid-operated time marker pen is also included.

As illustrated, the recorder is contained in a portable hard wood case measuring 18in by 11½in by 7in and having a canvas carrying strap. The front of the case is mounted on hinges which are so arranged that the whole cover may be removed. A used chart may either be stored on a rewind spool on the clock or ejected through a slot in the front cover. Chart replacement can be done through an opening in the back of the recorder case. The amplifier unit contains a two-channel d.c. amplifier and a power pack. It is housed in a steel case which measures 13½in by 8in by 6in and is perforated for cooling.

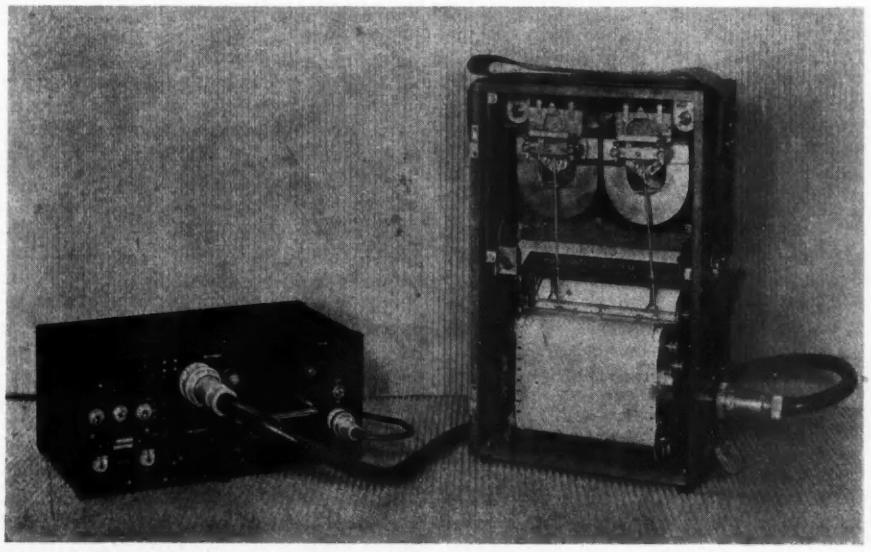
Each of the two channels on the chart is 2⅞in wide with a $\frac{7}{16}$in margin between them and each channel has ten large divisions subdivided into five small divisions. The scale divisions are spaced to allow for the fact that the pen traces an arc of a circle. The time lines are straight, being spaced at ¼in intervals. Provision is made for ink or Teledeltos recording.

The synchronous-motor-driven chart clock has a four-speed (lever selected) gearbox providing for chart speeds of ½in, 1in, 3in or 6in per second in the "RD.15" model, or 2in, 4in, 12in and 24in per minute in the "RD.15A" model. The power requirements are 140W at 200–245V, 50 c/s and, for the marker pen, a d.c. supply of 3W at 15–20V.

The maximum sensitivity may be set between the limits of ±10V to ±4V for a deflection of ±1$\frac{7}{16}$in to suit the user's requirements. It may be continuously reduced down to zero by means of a potentiometer control on the front panel of the amplifier unit. Provision is made to switch this control out of circuit if desired. The input impedance is approximately 50,000 ohms with the sensitivity control potentiometer in circuit and approximately 2 megohms with it switched out. The voltage across the resetting potentiometer is stabilised and the sensitivity is thus independent of mains variations.

Sine wave voltages up to 15 c/s can be recorded, with an amplitude error not exceeding 15 per cent for a peak to peak amplitude of 1½in. At smaller amplitudes the frequency response is proportionally higher. Linearity is within ±3 per cent.

After an initial warming up period of half an hour, the drift is less than half a small chart division over a period of three hours, that is, less than 1 per cent of full scale deflection.



Two-Channel Quick-Response Recorder with Amplifier Assembly on the Left

THE ENGINEER

Vol. 197 FEBRUARY 5, 1954 No. 5115

LEADING ARTICLES—

"What's Past is Prologue" 210
Large Freight Locomotives 210
The World Bank and Engineers 211

ARTICLES—

Aircraft Hydraulic Test Rigs. No. II. (Illus.) 213
American Research 193
Automatic Measurement and Control Instrument. (Illus.) 221
British Non-Ferrous Metals Research Association 221
Delayed Action Insecticidal Smoke Bomb. (Illus.) 217
Engineers' Tool Factory. (Illus.) 222
Example of the Plastic Method of Structural Design 193
Guided Missile Control 223
High-Temperature Turbine Machinery for Marine Propulsion. No. III. (Illus.) ... 194
Improving Modern Locomotive Performance. No. I. (Illus.) 202
Incorporated Plant Engineers' Dinner 193
Large Transonic Wind Tunnel. (Illus.) 205
Locomotives for the Spanish National Railways. (Illus.) 206
Mechanised Materials Handling Plant for a Foundry. (Illus.) 223
Motor Ships for the Clyde. (Illus.)... 200
Operational Research Society 193
Oxygen Cutting Machine. (Illus.) 224
Post-Graduate Technical Courses 193
Progress of the Metropolitan Water Board's New Works in 1953. (Illus.) 219
Regulations for the Electrical Equipment of Buildings 212
Research and Development Work in the Gas Industry 220
Rotating Self-Cleaning Air Filter 222
Self-Sealing Pipe Coupling. (Illus.) 224
Society of Engineers 193
Some Model Experiments on Special Control Valves. No. I. (Illus.) 207
Stresses in a Crane Jib. (Illus.) 196
Tractor-Driven Industrial Equipment. (Illus.) 216
Two-Channel Quick-Response Recorder. (Illus.) 209
Visit to an Oil Engine Works. (Illus.) 218

LETTERS TO THE EDITOR—

Torrents of the East Lyn and West Lyn 212
Launching Slipways. (Illus.) 212

LITERATURE 211

NEWS AND NOTES—

British Patent Specifications. (Illus.) 227
Contracts 226
Forthcoming Engagements 228
Industrial and Labour Notes 225
Launches and Trial Trips 228
Notes and Memoranda 226
Personal and Business 226
Technical Reports 215

FOLDING INSET—

Stresses in the Jib of a 10-Ton Derrick Crane

"WHAT'S PAST IS PROLOGUE"

Since the war British industry has been subjected to a series of critical investigations with the object of finding ways and means of increasing productivity. Teams of British and American experts have crossed the Atlantic to see how things are done on the other side. Under the ægis of the Anglo-American Council on Productivity, and later the British Productivity Council, they have compiled voluminous reports and made numerous recommendations, some of which have been reviewed in these columns. Few industries have escaped this searching form of scrutiny and the British electricity supply system is no exception. Towards the end of 1949 two British teams representing the supply industry visited the United States and in due course a report was published. In the spring of 1952, at the invitation of the British Electricity Authority, a reciprocal visit was made by a team of seventeen men drawn from the electric utility industry of the United States. During its tour this team visited some forty-eight centres, covering all the Divisions and Area Boards in England, Wales and the southern half of Scotland; the team also saw a boiler works and a switchgear works. Its findings were given in a report published in April, 1953. This report, containing as it does a fairly comprehensive evaluation of the British electricity supply system, has been closely studied by the B.E.A., the Area Boards and the National Joint Advisory Council of the electricity supply industries. Then, a few weeks ago, the B.E.A. published a memorandum containing the considered comments of these bodies on the conclusions and recommendations detailed in the report of the American team.

In last week's issue we summarised these recommendations and comments. Our purpose in returning to this subject is not to discuss these points in detail. It is rather to emphasise the common ground in these two viewpoints; and to show that the divergences of opinion are largely the result of differences in geographic and economic conditions and, therefore, in outlook between the two countries. There is general agreement, for example, about the need for installing larger turbo-alternators, with single boilers. Progress in this direction has hitherto been limited by the consideration that a more rapid increase in aggregate capacity could be achieved by relying mainly upon established designs. Increasing provision is, however, being made for larger sizes in the plant programmes for 1955–60. During this period fourteen sets of 120MW capacity are due to be commissioned and the "average size" of set installed will increase from 50MW to 77MW. British-built sets of 180MW rating are visualised, using hydrogen-cooled rotor coils and oil-cooled stators. The need to lengthen the period of turbo-generator overhauls from three years, as at present, to four or five years is accepted. It is based on the precept that turbines should be kept in service until there is some evidence of abnormality, such as excessive vibration or diminished efficiency. The application of these principles depends largely on improved instrumentation and full supervisory equipment which is being provided for new sets of 60MW and more. Somewhat different considerations affect the change in boiler inspection law advocated by the Americans, whereby boiler availability "could be increased by about 3 per cent." Here the British Electricity Authority is examining the existing arrangements in the light of the suggestion that the fixed period between boiler inspections by insurance companies should be abandoned in favour of a period of one, two or three years, to be determined by the inspector according to the condition of the boiler. When we turn to the transmission and distribution of electricity we find that the differences of opinion are more marked. The Americans recommend a review of the British decision to transmit large blocks of power towards the coastal cities from plants centrally sited near coal mines, rather than to haul the fuel. The B.E.A., on the other hand, contends that, over distances of more than about 50 miles, it is generally cheaper to transmit electricity from the coalfield to the area of load than to carry coal by rail to that area. In support of this contention the B.E.A. quotes a recent statement by the American Bureau of Reclamation that "the margin of 18 per cent in favour of electrical transmission of bulk energy . . . justifies serious consideration of an extra high-voltage transmission system in making plans for the future power needs of the West." On several occasions, says the B.E.A., the question of bulk transmission in Great Britain has been re-examined in detail and each review has confirmed the economic soundness of the project to build the 275kV supergrid. A more general recommendation made by the Americans is that the B.E.A. should liberalise the concept of equipment loadings, with due regard to emergency ratings, to make better use of existing equipment. With certain reservations this recommendation is accepted by the Authority in relation to the loading of cables, transformers and switchgear. These matters are under active review and, in particular, consideration is being given to the possibility of increasing the emergency ratings of lower-voltage overhead lines.

Probably the greatest measure of agreement, in principle, between the American and British viewpoints, is to be found on questions affecting labour relations. The Americans stress the need for greater wage differentials in recognition of the value of skills; they also recommend that trade union members should be educated "on the need for increased productivity to raise the workers' standard of living." The same need applies just as forcibly to the whole of British industry. It is the crux of the matter, but, unfortunately, by constant reiteration it has been degraded to the level of a platitude. The problem is largely one of education, and here, under the guidance of Lord Citrine, the British Electricity Authority, with its spring and summer schools and training courses, has set a standard for nationalised industries. It is characteristic that, having done so much already in this field, the Authority should accept the American suggestion for further expansion of training activities. It is in line with the policy of the industry since vesting day and it justifies its adoption of the slogan "What's Past is Prologue."

LARGE FREIGHT LOCOMOTIVES

The first of the long-expected new freight locomotives for heavy mineral traffic has just been completed at the Crewe Works and was described in our pages last week. It will be seen that this is a ten coupled design representing an advance in size and power compared with engines normally employed for working freight services on British lines and therefore seems to suggest that much heavier freight train loadings are expected in the future or possibly alternatively higher average speeds. As a type the design is not new, being generally similar to the ten coupled locomotives built in 1944 for the Ministry of Supply, a number of which have been in use on the railways for some time past, and, further, it may be remembered engines of

this particular type took part in the Interchange Locomotive Trials of 1948.

The new locomotives are not described as a "Standard" type for British Railways, though the fact that a number are to be built not only at the present time, but also as part of the coming programme, seems to indicate that it is expected that these large engines have come to stay. The design as such closely resembles that of the engines of 1944, of which it may be said to be an elaboration. Actually, the new locomotives can almost be said to be a redesign of the former engines, having larger cylinders and driving wheels and a higher working pressure. The tractive force is higher at 39,667 lb, compared with 34,215 lb for those previously built, while other modifications have resulted in an increase in the weight of the new engine to 86·7 tons as against 78·6 tons. The boilers are very much alike as far as total heating surfaces go—2550 square feet and 2374 for the new and older engines respectively. The evaporative heating surfaces are 2015 and 1951 square feet, so that the engine weights for each square foot of heating surfaces are 96 lb and 90 lb. The grate areas are practically equal, being 40·2 and 40 square feet; likewise there is little difference in the size of the fireboxes, the heating surfaces being 179 and 178 square feet, but the latter is augmented by 14 square feet due to the earlier design being fitted with arch tubes. The new engines are, it is interesting to note, the largest built in railway shops for British lines since the two experimental "Mikado" type engines designed by Sir N. Gresley for the L.N.E.R. in 1925. Those engines were, however, in advance of their time as the trains they could handle were found inconvenient in certain respects.

The new ten coupled locomotives, like the former examples of the so-called "Decapod" type, represent a design that has never been extensively used, though at one time it found a certain amount of favour in North America, more especially on the Pennsylvania system. For really high powers it leaves something to be desired so far as firebox proportions are concerned. But that may not be a matter of importance for the new engines now under notice, which no doubt will readily operate any freight trains that can be safely handled, providing the engines are economically used. They may be expected to work heavy through freight services over all normal grades without assistance, which, no doubt, is advantageous, but, at the same time, it is to be remembered that unless working schedules are correctly formulated the ton-miles made on more level sections will suffer owing to inadequate train loadings. The engines have certain features in common with the larger two "standard" classes. Those features have been worked into what is, in fact, largely the original design. As has happened to other redesigned locomotives, there has been some increase in weight in the process. But there do not appear to be any changes in the new locomotives which may be expected to improve fuel consumption in relation to power output. All that can really be said for the design is that it follows long-standing practices without anything displaying particular originality except perhaps in the fitting of smoke deflectors for the first time to a heavy freight engine!

THE WORLD BANK AND ENGINEERS

Banking is a subject that seldom comes within the "terms of reference" of this technical journal. Yet many engineers could read with profit a document just issued by the Federation of British Industries. It discusses the operations, the organisation, and the staffing of the "World Bank"—or, to give it its proper title, the International Bank for Reconstruction and Development. The issue of the document follows upon a visit made by a small group on behalf of the Federation to see how the Bank operates. Some important conclusions emerge. That the work of the Bank is of deep interest to engineers is indicated by the fact that it has made loans totalling some 1500 million dollars to cover eighty-five projects in twenty-nine countries and has a large number of additional projects under consideration. The bulk of these projects are engineering ones. Moreover, it appears to be the opinion of the Bank that it is more likely to have its activities limited by a dearth of suitable projects than by any lack of money with which to finance them.

Every separate project put up to the Bank is carefully examined technically as well as economically by the Bank's staff. The Bank may require a borrower to employ approved professional consultants, or employ them itself. It can exercise a veto, or impose special conditions, if the competence of a contractor, making a successful tender, is felt to be in doubt. Under certain circumstances it can even veto a borrower's choice of type of equipment to undertake a certain job. Those are only some of the things it can do. But their mention alone is sufficient to show that British consultants, contractors and manufacturers need to take a close interest in its operations. The F.B.I. party was fully convinced by what it saw that the Bank's staff had become truly international in outlook. But it felt nevertheless that, though the Bank has its own economic, agricultural and other specialists, it could make wider use of special consultants having expert knowledge of conditions in particular territories; and it is also felt that methods by which candidates from this country are put forward for that purpose, or for filling vacancies on the Bank's staff, need review here, at home. It is particularly disturbing to learn from the document that though there is a reasonably satisfactory proportion of British people on the Bank's staff, none of them are engineers. For it is obvious that unless there are British engineers on the staff, knowledge is likely to be lacking in the Bank about the quality and reputation of British consultants and tenderers and of British equipment. The Bank's impartiality is not here impugned. The fault does not lie with the Bank, which desires to recruit a truly international engineering staff, but with the quality of British engineers who have applied for posts. We are very glad to learn that this matter is to be taken up "in appropriate quarters" in this country by the F.B.I. The Federation is also taking up another matter. It relates to the information becoming available about the priority and backing being given by the Bank to particular schemes, information which, through no fault of the Bank itself, seems often to be obtained by our competitors in Germany, the U.S.A. and even Japan before it reaches British engineers and contractors. The World Bank is likely to play in future a large part in making capital available for major engineering projects all over the world. The Federation is to be commended upon drawing attention to its operations.

Literature

History of Railway Locomotives Down to the End of the Year 1831. By the late C. F. DENDY MARSHALL, M.A. London: The Locomotive Publishing Company, Ltd., 88, Horseferry Road, S.W.1. Price 50s.

THE author of this book was for long recognised as a leading authority on early locomotive matters. Numerous books have been written on what might be termed the middle and later years of steam locomotive history, but it is doubtful if any other author concentrated so much on the first years of the locomotive than Dendy Marshall. Much research has been carried out into early locomotive history—as the many articles which have appeared in our pages over the years testify—but this book will be welcomed as probably the most worthy of the subject which has yet been published. It will be recollected that Ahrons' classic work *The British Steam Locomotive* commenced with the year 1825, so that the volume under review may be regarded as in many ways a complementary work.

Those who have studied early history will not always agree with some of the author's conclusions, but locomotive history is similar to much other history in that, despite every research, many points remain contentious. The conclusions reached by Dendy Marshall will, however, be welcomed by and be acceptable to the majority of students of locomotion, particularly those who know the great lengths to which he went in his attempts to accumulate and confirm facts.

The arrangement of the book may, at first glance, be a little disappointing, for it has been arranged in chapters dealing with individual builders and not in chronological order. But readers will find, on balance, this proves to be a very good method of presenting the material. The following list of the chapters of the new book gives an impression of the field covered:—Steam Power and its Application to Locomotion; Richard Trevithick; Blenkinsop and Murray; Taylor Swainson; William Chapman; William Hedley; William Brunton; William Stewart; George Stephenson; Robert Stephenson and Co.; John M'Curdy; Robert Wilson; Timothy Hackworth; Braithwaite and Ericsson; Timothy Burstall; John Urpeth Rastrick; Bury and Kennedy; Neath Abbey; Rothwell and Hick; Goldsworthy Gurney; George Dodds; Miscellaneous British Builders; Early Attempts on the Continent; Marc Seguin; The United States of America.

It will be seen from this list that not only are all the early British locomotive builders covered, but work done in France and America within the period concerned is included. Naturally, not all of the material presented is new; inevitably much of it has appeared elsewhere, including some of the author's earlier books. But the new book provides a convenient single source of valuable information which was previously spread over a number of publications.

The book is well illustrated and pleasingly presented, and it will, without doubt, be a valuable addition to the libraries of all those who are interested in early locomotive history.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

TORRENTS OF THE EAST LYN AND WEST LYN

SIR,—In his letter of October 28, 1953, Mr. Thompson suggests that at certain sites where he considers that "the water must have come down . . . in a series of cascades," the discharge could be estimated from the weir formula :

$$Q=3\cdot1B\,.\,h^{3/2}\,.$$

In making this suggestion, it is clear that he regards the case as that of a long-throated rectangular flume of width B. Difficulty in applying the formula arises from the fact that the total head h above the bed of the flume cannot be directly measured, since "h will include, besides the measured depth, an allowance for the head due to velocity of approach." The term "velocity of approach" implies the conception of a gauging section, where, for an observed depth of flow, the waterway area A is known and the velocity of approach V is correctly given by $V=Q/A$.

Mr. Thompson arrives at an approximate value for V of $3\cdot1h^{3/2}$ by dividing the discharge $Q=3\cdot1Bh^{3/2}$ by a sectional area of $B\,.\,h$, thereby disclosing that his imagined gauging section has the same width and bed level as the flume, and is therefore indistinguishable from it. This being the case, he might at once have realised that what he was measuring at the gauging section was the critical depth of flow D known to be two-thirds of the total head h. Putting $h=\frac{3}{2}D$, the weir formula would then have given :

$$Q=3\cdot1B\left(\frac{3}{2}D\right)^{3/2}=5\cdot68BD^{3/2}=\sqrt{g}BD^{3/2}$$

this being the product of the sectional area BD and the critical velocity $\sqrt{gD}$.

Alternatively, D being the depth measured at the gauging station where the sectional area is BD—not Bh, as assumed by Mr. Thompson—the velocity of approach is $V=\frac{Q}{BD}$, so that the total head is $h=D+\frac{V^2}{2g}=D+\frac{1}{2g}\left(\frac{Q}{BD}\right)^2$, and the weir formula gives :

$$Q=3\cdot1B\left(D+\frac{1}{2g}\cdot\frac{Q^2}{B^2D^2}\right)^{3/2}.$$

This implicit relationship between D and Q is satisfied by giving the correction term $\frac{V^2}{2g}=\frac{1}{2g}\left(\frac{Q}{BD}\right)^2$ a value of $\frac{1}{2}D$. This gives :

$$\frac{1}{2g}\cdot\frac{Q^2}{B^2D^2}=\frac{D}{2}\qquad(\text{or } Q=\sqrt{g}\,.\,BD^{3/2})$$

and, as required to satisfy the relationship,

$$Q=3\cdot1B\left(D+\frac{D}{2}\right)^{3/2}=5\cdot68BD^{3/2}=\sqrt{g}\,.\,BD^{3/2}$$

as before.

To exemplify his proposals, Mr. Thompson takes the case of the West Lyn at Lynbridge and estimates the discharge as :

$$Q=3\cdot1\times50\times12\cdot0^{3/2}=6435\text{ cusecs}$$

without, however, stating what was the measured depth, and what allowance was made for the velocity of approach to arrive at a total head of 12·0ft. The matter is elucidated by referring to Table II of the I.C.E. paper on "The Lynmouth Flood of August, 1952," by Messrs. Dobbie and Wolf, where cross section No. 336 of gauging station No. 12 is shown as having a sectional area of 610 square feet and an H.M.R. of 8·5ft. If this is not the same site as that considered by Mr. Thompson, it must be very near to it and in the same reach. With a measured depth of 12·0ft Mr. Thompson's rectangular section would have a sectional area of 600 square feet and an H.M.R. of 8·1ft. The two sets of figures are in sufficiently close agreement to justify the conclusion that in Mr. Thompson's calculation the figure of 12·0 represents merely the measured depth, and that he has, surprisingly, failed to apply any correction whatever for velocity of approach.

If this inference is correct, the proper correction to apply was, as I have shown, no less than 6·0ft, giving the total head h a value of 18·0ft, and the discharge a value of $3\cdot1\times50\times18\cdot0^{3/2}=11{,}800$ cusecs—no less than 84 per cent larger than the 6435 cusecs of Mr. Thompson's calculation.

E. S. CRUMP

Wallingford, Berks,
January 21st.

LAUNCHING SLIPWAYS

SIR,—With reference to your report on the Beaumaris slipway, on page 43 of your issue of January 8, 1954, and Fig. 9 on the same page, it may be of interest to you to know that a similar type of slipway was designed and constructed by the Royal Engineers on Lake Timsah, on the Suez Canal, in 1941 for the launching of 200-ton landing craft. Restriction at site dictated such a type of slipway with building berths at right angles to the line of the slipway. Building berths extended 324ft and 216ft either side of the slipway, on which craft were constructed and then sideslipped to the launching cradle on timber sliding ways running on timber standing ways. The cradle consisted of a steel framework carried on six lines of 60cm Decauville track chassis, each line consisting of thirteen such chassis. The enclosed photographs show a landing craft on the cradle prior to launching and a general view of part of the building berths. An article describing the construction of the shipyard and the work undertaken in it, varying from 200-ton landing craft to 100-ton sailing schooners, will appear in the March, 1954, issue of the *Royal Engineer Journal*.

J. H. D. BENNETT

Hounslow, Middlesex, January 14th.

Regulations for the Electrical Equipment of Buildings

A SUPPLEMENT to the twelfth edition of the *Regulations for the Electrical Equipment of Buildings* has been issued with the approval of the Council of the Institution of Electrical Engineers. This supplement takes account of the changes arising from the issue of revised British Standards for rubber and p.v.c. cables by the British Standards Institution in August, 1953, as follows :—B.S. 7, "Rubber-Insulated Cables and Flexible Cords for Electric Power and Lighting," and B.S. 2004, "P.V.C.-Insulated Cables and Flexible Cords for Electric Power and Lighting."

Cables conforming to the new Standards are acceptable for the purpose of the Regulations with the following exceptions :—

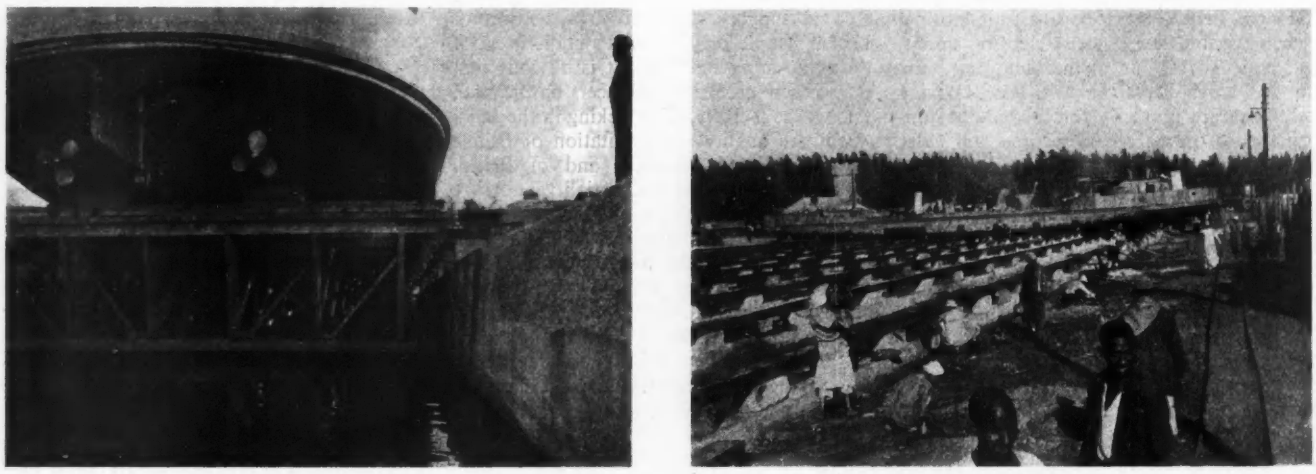
(*a*) The use of parallel twin rubber or p.v.c.-insulated flexible cords is not recognised.

(*b*) Tough-rubber-sheathed flexible cords with further reduced thickness of rubber insulation may be used only with vacuum cleaners. Twisted twin flexible cords with thickness of rubber or p.v.c. insulation further reduced may be used only for pendant lighting fittings.

(*c*) The use of twisted twin p.v.c.-insulated flexible cord without colour identification of cores is not permissible.

In other respects the supplement validates the revised British Standards for the purposes of the Regulations, and in particular contains an alternative Table 22 for numbers of 250V grade cables which may be drawn into conduit when cables manufactured to the revised Standards are in use. It is pointed out that the tables of the existing twelfth edition continue to apply where cables manufactured to the former Standard are in use.

A separate and corresponding supplement has been issued amending the *Abridged Wiring Regulations*, which were first issued in November, 1951. The *Temporary Relaxation* to the twelfth edition (and to the *Abridged Regulations*), issued in December, 1952, dealing with the current rating of cables up to 7/·029in, continues in force. The two supplements mentioned above can be obtained (price 6d. each), from the Institution of Electrical Engineers, 2, Savoy Place, London, W.C.2.



Landing Craft on Launching Cradle and (Right) Part of Building Berths on Lake Timsah, Suez Canal, 1941

Aircraft Hydraulic Test Rigs

By R. T. SEWELL*

No. II—(*Continued from page 165, January 29th*)

The increased complexity of high-pressure hydraulic systems for modern aircraft has resulted in a new approach to the problems of testing. The method of test and the design and use of test rigs is discussed, with particular emphasis on the necessity of testing complete systems under fully representative conditions.

Endurance Testing.—With the majority of hydraulic line components, 10,000 trouble-free operations under maximum operating conditions should be the least target. On emergency services, a lower target is acceptable; on the other hand, components in a main power circuit may be expected to complete not less than 50,000 operations without failure.

It is hardly possible to cover all the aspects of endurance testing within the scope of this article. The most common causes of failure, apart from normal wear of valves and valve seats, are extrusion and wear of sealing rings, fatigue failure due to repeated load or

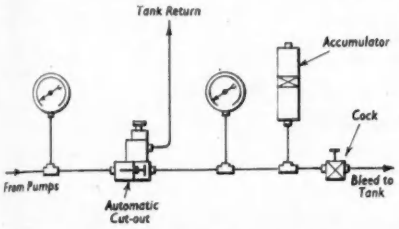


Fig. 11—Test Circuit for Automatic Cut-out

pressure reversals (particularly common in components using light-alloy forgings) and failure due to unforeseen stress-raisers.

Rigs and equipment for endurance testing should be so designed as to require the minimum of attention while running. Automatic control of selectors and other valves, whether mechanical or electrical, should be used whenever permitted by the nature of the test in progress so that an hourly inspection is all that is necessary. If careful thought is given to the hydraulic circuit layout, several components may be tested simultaneously.

For most endurance tests, the hydraulic power requirements are small, and can be obtained from a small power pack consisting

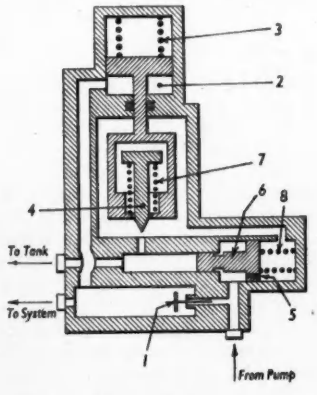


Fig. 12—Automatic Cut-out. Schematic Diagram

of an electrically driven pump, with cut-out, relief valve, &c., the whole being mounted within a wheeled framework for easy transportation. If the power requirements are greater, such as in the testing of automatic cut-outs and selectors where a high rate of flow is required in order to obtain correct operating conditions, then recourse is made to the four-pump rig described in the section on "Flow Testing."

A typical layout for the testing of an automatic cut-out is shown in Fig. 11. This component is used in an aircraft system to off-load the pumps when a predetermined system pressure is reached, and to bring them on-load again when an operational demand results in a reduction in system pressure.

The cut-out is shown schematically in Fig. 12, the method of operation being as follows. Normally, the flow from the pump passes through the non-return valve (1) to the system, which is provided with an accumulator. When the system pressure rises to the predetermined maximum (e.g. 4000 lb per square inch) the pressure in the annular chamber (2) reacts against the spring (3) and lifts the valve (4) from its seat. The flow of oil which now takes place through the orifices (5) in the by-pass valve (6) sets up a drop in pressure sufficient to lift the by-pass valve off its seat, and thus off-loads the pump to tank. The non-return valve (1) now closes, leaving the system under pressure until a demand causes this pressure to drop. At the moment when the valve (4) opened the spring (7) lifted it fully off its seat. This valve will now only be able to reseat when the system pressure in the annular chamber (2) drops to a predetermined value (e.g. 3500 lb per square inch), whereupon the valve (4) closes, the flow through the orifices (5) ceases, the by-pass valve (6) closes under the influence of the spring (8), and the pump cuts-in, restoring the system pressure to 4000 lb per square inch, when the cycle is repeated.

Referring to the line diagram, Fig. 11, the method of test is as follows. The pumps are started with the cock open, and run-up to the required speed. The cock is then closed, when the system pressure in the accumulator builds up and the pumps are off-loaded. The cock is then opened slightly, allowing the system pressure to drop until the pumps come on-load again. The frequency of operation is governed by the degree of opening of the cock, and for most tests is about 30 cycles per minute. A small pressure-operated switch is teed off from the inlet line; this operates an electrical counter recording the number of cycles.

The problem of wear of valves and valve seats can usually be settled by choice of suitable materials, as determined on test.

Failure of sealing rings is a frequent cause of trouble in hydraulic components. The most common failure experienced with high-pressure components is extrusion of the ring under the influence of pressure into the gap between the male and female mating parts, aggravated by expansion of the cylinder.

The behaviour of seals under different working conditions tends to become a subject for specialised development. A test jack specially designed for the investigation of seal problems is shown on Fig. 13. The seals under investigation are those marked *A* on the piston and *B* in the gland carrier. It will be seen that a detachable cylinder is fitted inside the main cylinder. The advantages of this design are, that by changing only the inner cylinder and piston it is possible to (*a*) test piston rings of varying sections and diameters, and (*b*) study the effect of piston and cylinder materials and surface finishes.

Failure of components may also occur during repeated pressure reversals, either due to local stress-raisers, or in light-alloy components, due to faulty forging technique. It is important to establish the minimum life of light alloy components by means of impulse testing at a pressure 25 per cent higher than the maximum system pressure (this is in order to cover the scatter).

A typical test layout for a small hydraulic

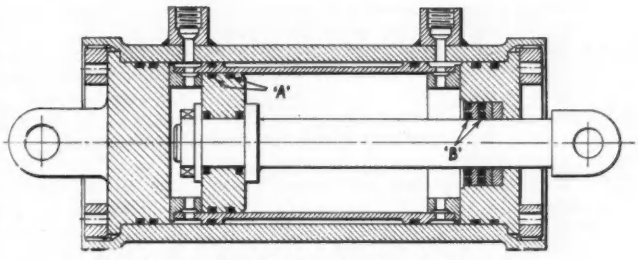


Fig. 13—Test Jack for Investigation of Sealing Rings

jack is shown on Fig. 14. Hydraulic power is obtained from a portable power pack, and admission of pressure to the full and annular sides of the jack is controlled by the mechanically-operated selector. The capacity chamber was in circuit to equalise approximately the two volumes, the jack being fixed in the almost fully closed position. The purpose of the sleeve on the annular side of the jack was to relieve any load on the piston-

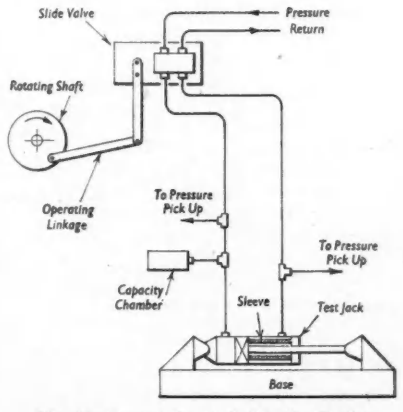


Fig. 14—Layout for Jack Impulse Testing

rod. Electronic pressure pick-ups were fitted on both sides of the circuit, and recordings taken of the pressure/time characteristics. Recordings taken during an actual test are shown on Fig. 15.

Special Functional Testing.—Certain hydraulic components designed for one specific purpose may require special rigs to assess their performance. A typical example is a flow divider, a component designed to maintain equal division of a given input rate of flow with a maximum error of 1 per cent to 5 per cent (depending upon the application) under all conditions of back pressure, that is, the operating pressure demanded by either one of the two jacks to which the out-

* British Messier, Ltd., Gloucester.

lets of the divider are connected. On the aircraft itself, the jacks would operate control surfaces which must move together irrespective of the aerodynamic loads. Unequal movement may result in a rapid change of trim which the pilot might not be able to control.

The line diagram of a flow divider test rig is shown on Fig. 16. A rate of flow equal to the design rate of flow is put through the divider, and on each outlet, the back pressure is controlled by the setting of the cocks. Pressure gauges are tapped in to indicate the inlet pressure and pressure at each of the two outlets. After passing through the divider, oil is taken straight back to tank or by-passed into measuring cylinders when measurement of flow is required. A selector is included to reverse the direction of flow, being achieved through the non-return valves without altering the setting of the cocks. A reverse flow test is necessary to prove correct functioning when oil is being returned from the jacks.

This rig will do all that is necessary for routine production testing, and investigation, but sometimes it may be necessary to conduct tests under correct operating conditions using differentially loaded jacks. This kind of rig is shown on Fig. 17. The outlets of the divider are connected to the test jacks which are loaded by hanging weights on the beams. The jacks operate in tension only, the full-area sides being vented to atmosphere (the divider operates in one direction only).

The same loading rig could also be used for testing jack synchronisers, a component which performs the same functions as the flow divider, but is operated mechanically through cables connected to the jacks.

While the loading rig described satisfies certain requirements in that different loads are applied to the jacks, the loads are in tension only. A loading condition may arise in service where one jack operates in tension and the other in compression. Such a condition may be duplicated by using reaction jacks to apply the loads. The design and use of reaction jacks is more fully described in the section of this paper dealing with complete aircraft systems.

An interesting rig designed for testing a hydraulic motor is shown on Fig. 18. The motor is used to drive a pneumatic brake, and also drives a secondary screwed shaft, upon which is mounted a cam. A spring-loaded plunger kept in contact with this cam operates an infinitely-variable reducing valve which controls the pressure in the brake, and hence, the torque applied to the motor. Different torque loadings are obtained by altering the shape of the cam. If the motor is controlled by electrically operated valves, limit switches are fitted at the extremes of cam travel. Linkages can be used if the control is mechanical.

Testing of Complete Aircraft Systems

In order to assess the performance of individual components when forming a complete aircraft system, full-scale test rigs are built on which the actual aircraft installation is duplicated as far as possible regarding sizes and lengths of piping, geometric layout of the components, and applied loads on the operating jacks. It should be emphasised that no amount of bench testing of components, however thorough, can simulate the conditions likely to be obtained on the aircraft. It is only on a full-scale test rig that the effect of long pipe lengths, various loading conditions, and interaction of the services can be determined.

The actual construction of the rig does not present any undue problems, since it is only a question of designing a suitable framework with correct jack attachment points, &c., and paying due regard to the structural strength taking into consideration the results of the applied loads. The rig designer's greatest problem is in simulating the aerodynamic loading conditions. The aircraft manufacturer will supply the rig designer with details of control surface loads and operating times required, and it is then his job to design a mechanism that will result in the correct loads being applied to the jacks. It is very rarely possible to duplicate exactly the conditions, so the aircraft manufacturer must be willing to accept the best compromise that the rig designer can offer.

It should be pointed out that the actual aircraft parts, such as bomb doors and flaps and their respective operating linkages, are not always used on a full-scale rig, unless it is considered that their weight and stiffness will affect the operation of the hydraulic jacks. Certain complicated linkages may be installed on the test rig so that the aircraft manufacturer may satisfy himself as to their correct operation.

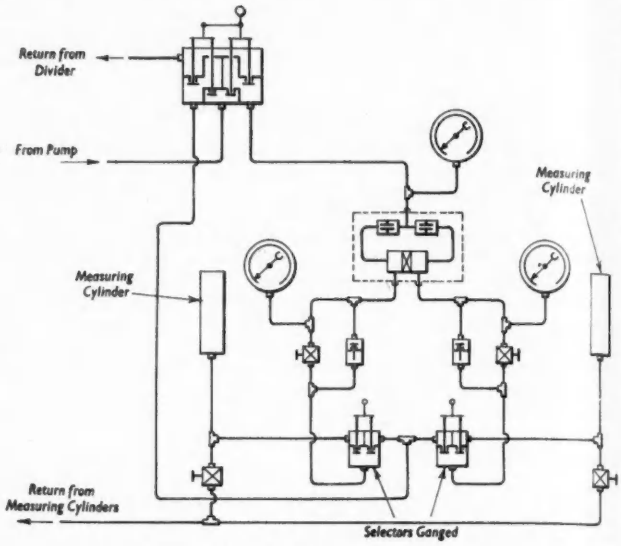


Fig. 16—Flow Divider Test Rig. Hydraulic Line Diagram

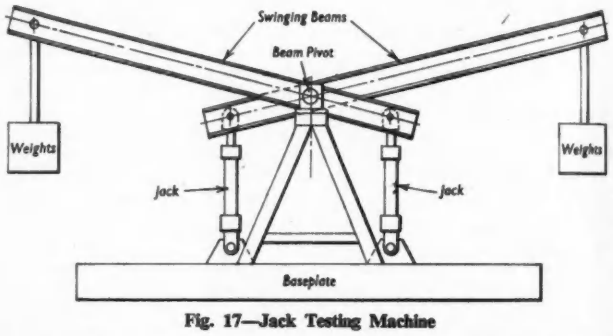


Fig. 17—Jack Testing Machine

It is usual to use the actual aircraft undercarriages on retraction test rigs since the design and manufacture of suitable dummies would be unnecessarily complicated and expensive.

Since it is the actual methods of simulating the loading conditions which are likely to present the greatest problems, some of the known and used methods will now be discussed.

Undercarriages.—This section deals with the simulation of loads on the undercarriage itself. Hydraulically operated undercarriage doors are considered separately.

The loads to be considered are those due to changes in acceleration during take-off and landing, aerodynamic loads and, in some cases, loads on the undercarriage due to fairing doors which are mechanically operated by the undercarriage during raising and lowering.

The effects of changes in vertical acceleration are to increase or decrease the effective moment of the undercarriage about its swivel axis. This is best achieved on the rig by fixing weights to the undercarriage wheel axles so as to give the required total moments. The normal operating limits are between 0·8*g* and 1·3*g*, but with some modern fighter aircraft, the loads due to acceleration on take-off may be as high as 3*g*, effective during retraction only.† While this can be simulated by adding weights to the axles, it may prove

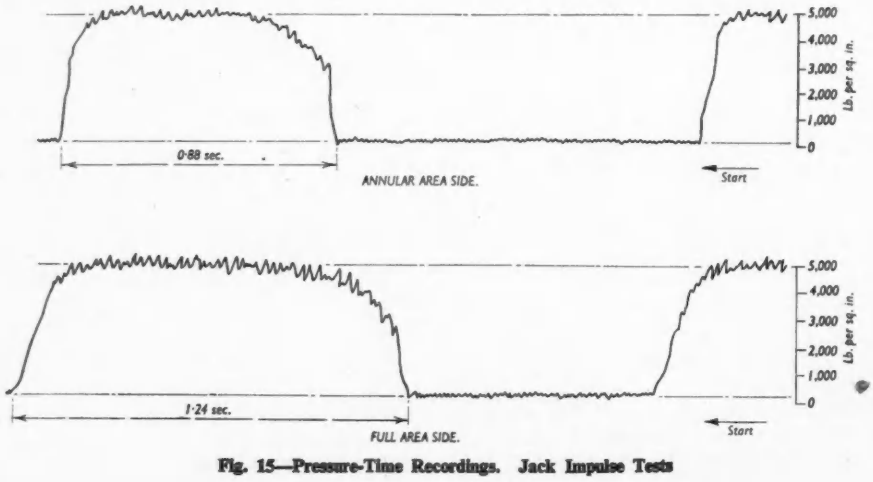
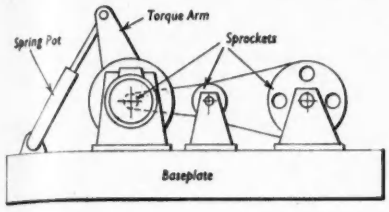


Fig. 15—Pressure-Time Recordings. Jack Impulse Tests

necessary to provide a means of removing the excess weights when locked up, as lowering with the weights on may cause damage due to excessively rapid movement.

A further operational requirement is that, should the undercarriages be stalled during



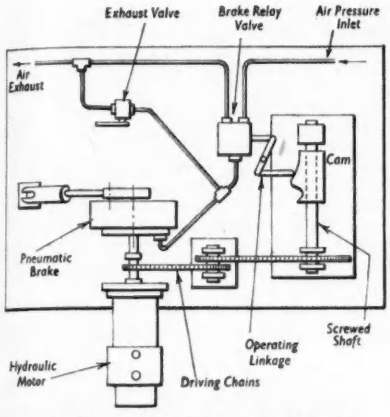
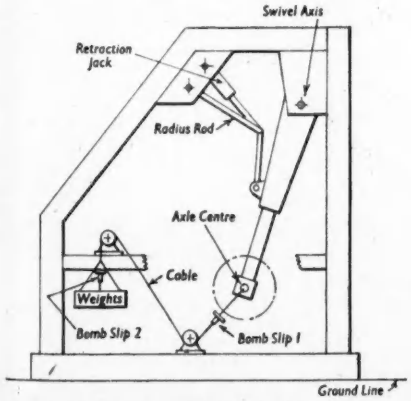


Fig. 18—Hydraulic Motor Loading Rig

movement by an increase in vertical acceleration beyond the normal operating range, then movement should continue without attention once the stall load is removed. In the past it has been usual practice to stall the undercarriages at some point during raising by fixing a cable to the undercarriage with the remote end of the cable held in a quick-release mechanism.

The method, while easy and cheap, is not satisfactory, as it does not reproduce conditions on the aircraft. With the application of increased acceleration there may be a tendency for the undercarriages to fall back, which could result in an excessive pressure rise in the operating jack.

An entirely satisfactory method which has been developed is shown diagrammatically on Fig. 19. Excess weights are held by a quick-release to a fixed member of the test



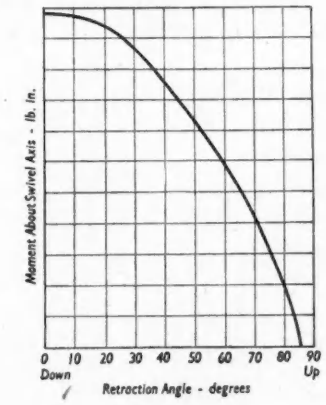
Raising : Weights supported by Bomb Slip 2. Cable comes tight at desired point during retraction and undercarriage is stalled. Bomb Slip 2 released, allowing weights to drop on to cable to check falling back. Bomb Slip 1 released, allowing weights to drop off, and undercarriage proceeds to retract.

Lowering : Weights on and Bomb Slip 2 released with undercarriage locked up. Undercarriage then lowered and Bomb Slip 1 released at desired point during lowering.

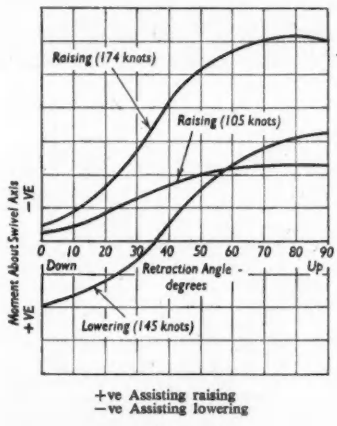
Fig. 19—Layout for Excess Acceleration Tests on Undercarriages

rig. These weights are such as to give the required increase in effective moment. Further cables are rigidly attached to the weights, pass over and under the pulleys, and are finally attached to the undercarriage by a second quick-release. At a predetermined point during retraction, these cables come tight and the undercarriage is stalled in attempting to lift the excess weights. The first quick-release is then operated, allowing the weights to drop on to the cables attached to the undercarriage. This will check the fall back. Finally, the undercarriage quick-release is operated, the weights drop off on to the ground, and the undercarriage proceeds to lock up. This scheme can also be used to apply excess acceleration loads during lowering.

On certain types of undercarriage it may be necessary to take into account the effects of lateral acceleration due to operation under yawed flight conditions. This can be simulated by fixing a spring-loaded plunger



(a) Drag Load



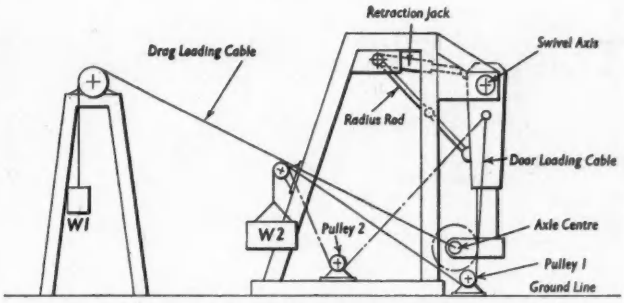
+ve Assisting raising
−ve Assisting lowering

(b) Door Loads

Fig. 21—Applied Loads on Nose Undercarriage During Retraction

to the undercarriage and arranging that the spring is compressed by passing over cams fixed to the rig structure. The load exerted by the spring is equal to the lateral acceleration component.

The aerodynamic loads to be considered are those due to air drag and horizontal acceleration. These effects can be simultaneously reproduced by attaching a cable to the undercarriage and hanging weights on



*W*1 gives drag load. *W*2 (first pulley) gives door load (raising). *W*2 (second pulley) gives door load (lowering).

Fig. 20—Drag and Door Loading Diagram For Typical Nose Undercarriage

the remote end, the weights and cable layout being chosen so as to reproduce the effective moment about the swivel axis. On some undercarriages the wheels may rotate about the vertical axis in order to fit into the fuselage or wing. The effects of the resultant increased load on the operating mechanism can again be simulated by a suitable weight and cable layout. On this type of undercarriage it may also be necessary to reproduce gyroscopic effects by spinning the wheels prior to retraction.

Loads due to mechanically-operated doors can be simulated by cables and weights or by additional weights on the undercarriage itself where the door is fixed to the leg in such a manner that no drag load is to be considered.

A diagrammatic representation of the method of applying drag and door loads and the resultant loading curves are shown on Figs. 20 and 21. It will be seen here that two cable layouts had to be used for simulation of door loads in raising and lowering, as the loading cases were widely different.

No standard layout can be used for undercarriage loading systems. Each geometry must be considered on its merits and loading systems devised accordingly.

(To be continued)

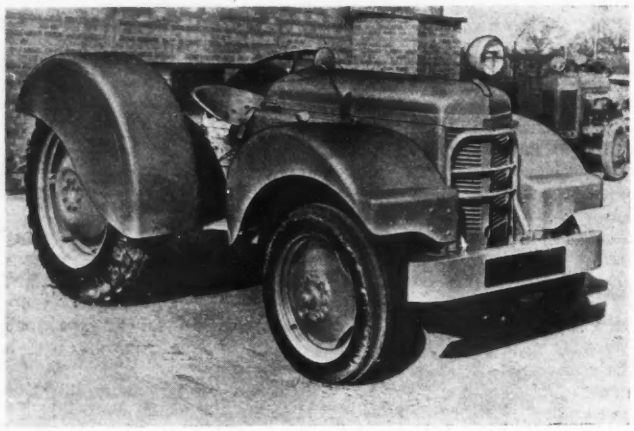
Technical Reports

Restriking Voltage Characteristics : Self Capacitances of H.V. Transformers, Reactors and Busbars (Ref. G/T272). By J. S. Vosper, B.Sc. (Eng.), A.M.I.E.E. The British Electrical and Allied Industries Research Association, Dorking Road, Leatherhead, Surrey. Price 15s., postage 4d.—This report relates, more particularly, to factors affecting restriking voltage characteristics of the British 132kV grid; and measurements, confined in the main to 132kV transformers and reactors, have been made by E.R.A. *in situ* on the grid. The plant on which measurements were made was electrically disconnected from the grid, and the phases were appropriately connected to represent the condition of the first phase to clear a three-phase unearthed short circuit. In this way measurements of effective self-capacitance were made on nine transformers in the range 37·5 MVA to 75MVA and on six reactors comprising 50MVA and 90MVA banks respectively. In addition, information on typical values of self capacitance of transformers has been received from various manufacturers. The manufacturers' data and the results of the above-mentioned E.R.A. measurements are compared and there is evidently a wide variation of self capacitance among different designs.

The results do not show any pronounced relationship between the effective self capacitance and MVA rating of plant ; in fact they suggest a minimum value (viz., 1000 $\mu\mu$F per phase for transformers and 500 $\mu\mu$F per phase for reactors) for all MVA ratings in the range considered. The results of a few measurements of 132kV busbar capacitances are also given and a value of about 40 $\mu\mu$F per phase per yard is suggested for 132kV busbars of standard low type construction. The effects of transformers and reactors in damping transient voltages were also deduced from the measurements referred to above and a damping factor of 1·85 is suggested for use in practice.

Tractor-Driven Industrial Equipment

IN recent years there has been increasing recognition of the usefulness of the power take-off and hydraulic lift systems of agricultural tractors. Tractors are no longer haulage machines only; they are satisfactory prime movers for a variety of plant used in mechanised farming and by public works contractors and municipalities. Last week, Eastern Tractors, Ltd., held a demonstration at its works at Springfield, Chelmsford, Essex, to show some of the work, outside usual farm operations, of which the Ferguson tractor is capable. At this demonstration the Ferguson industrial tractor was primarily used. As will be noted from an accompanying illustration, its basic design is similar to that of the agricultural model, with the addition of detachable mudguards to the wheels, and such other refinements as head lamps and side lamps, and a spring-loaded bumper to protect the front end. The tractor is available either with a petrol, vaporising oil, or a diesel engine, the latter being a four-cylinder engine of 2092 c.c. capacity, giving 28 belt horsepower, at 2000 r.p.m. The gearbox provides for four forward speeds between 3⅜ and 13¼ m.p.h. and a reverse speed of 3⅞ m.p.h. The overall length of the tractor is 10ft 4½in, its width over the rear mudguards is 5ft 9in, and there is a ground clearance under the front bumper of 14½in.

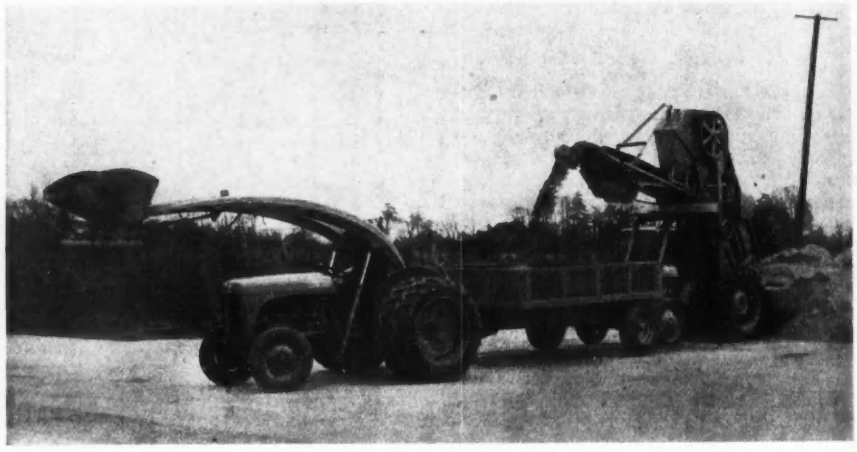


Ferguson Industrial Tractor

In addition to the tractors, the equipment manufactured by Massey-Harris-Ferguson, Ltd., of Coventry, which was working at the demonstration, included a post hole digger, which is available with 6in, 9in, 12in or 15in diameter augers and can work to a depth of 3ft, and the high-lift loader, which is illustrated herewith. This loader consists of a pressed steel framework comprising two main beams of oval section and suitable cross bracing. The frame is pivoted about an axis above and parallel to the tractor's rear axle, the pivot points being located on a detachable framework mounted on four pins on the back of the tractor. For the hydraulic operation of the loader there are two jacks, the bottom ends of which are attached to a removable beam mounted underneath the tractor, and the top ends of which are pivoted under the main beams. With the bucket attachment the loader can lift rather more than 10 cwt, the maximum discharge height being 8ft 6in.

The same illustration shows the "Autoloader," which is made by T. and T. Works, Ltd., and distributed by Modern Plant Autoloaders, Billesdon, Leicester. It is a mobile, self-loading elevator for picking up gravel, sand or similar material and delivering it into a transport vehicle. The "Autoloader," which can be attached to the rear of a tractor, is intended to deal with material of about 1in size and has been designed for an output of approximately 1 cubic yard a minute. The machine is assembled in a fabricated superstructure, which is bolted to the front engine bearers and rear axle of the tractor, and all its operations can be controlled by the tractor driver. At the rear of the superstructure there is an adjustable heavy-chain and steel-bucket elevator, the chain shaft at the bottom of the elevator being extended on each side to carry archimedean screw blades. A steel scoop at the foot of the elevator is raised or lowered by the hydraulic lift of the tractor, and when the machine is backed to the heap of material to be shifted the screw blades feed the material into the scoop from where it is picked up by the buckets, which are fitted with renewable digging teeth. The material is deposited by a discharge chute on to an 18in wide troughed belt conveyor, which is pivoted at a point immediately below the discharge chute and is so arranged that it can be rotated through an angle of approximately 180 deg. The drives to the elevating and conveying mechanism are all taken from the power take-off shaft of the tractor, the primary drive being by precision roller chain to a countershaft running in ball bearing plummer blocks. From there the drives are distributed by precision roller chains and vee ropes.

Another interesting machine which took part in the demonstration was the "Atos" tractor-operated shovel, shown in one of our illustrations. It is made by John Allen and Sons (Oxford), Ltd., Cowley, Oxford, and with its hoe bucket attachment can cut trenches up to 2ft wide and 8ft 6in deep. A shovel bucket in place of the trenching hoe enables the machine to excavate a bank of earth and load it to a maximum height of 12ft 9in, the capacity of an 18in wide shovel being 3·3 cubic feet. The steel frame is carried on 7·50 by 16 rubber-tyred tractor trailer wheels and the machine has an overall length of 18ft, its overall height with the boom lowered being 5ft 9in. Power for operating the hydraulic pumps of the shovel is transmitted through a Hardy Spicer universal joint from the tractor power take-off shaft running at 530 r.p.m. The hydraulic action forces the bucket through the ground, raises the boom and swings it to left or right. If the bucket comes up against an underground obstruction and the pressure consequently rises, there are by-pass valves which cut off the hydraulic power immediately. For the boom and bucket cylinders the pressure of the hydraulic system is 1000 lb per square inch, and for the swing rams the pressure is 750 lb per square inch. The operator controls all the digging actions, from a platform, by three vertical levers. There is one lever for raising the boom, one for controlling the bucket, and one for left or right swing. These controls self-centre when released with the result that all movement

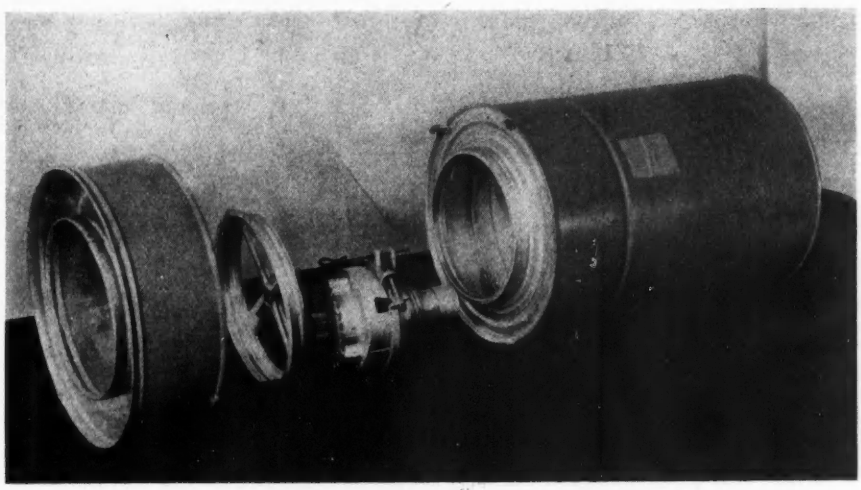


High Lift Loader and Self-Loading Elevator

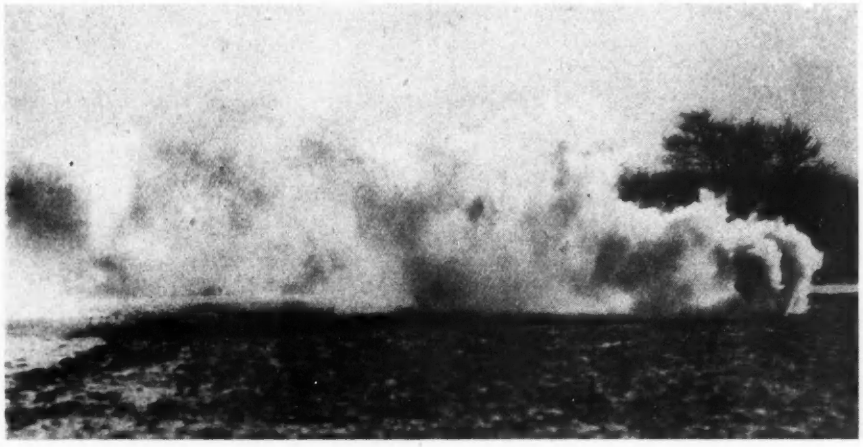
Tractor-Operated Shovel and Trenching Machine

of the boom and bucket is stopped immediately.

Among other equipment at the demonstration were tractor-mounted air compressors, supplied by the Atlas Diesel Company, Ltd., of Wembley, and J. C. Bamford, Ltd., of Rocester, Staffs, and a pole hole borer which has recently been produced by Taymen, Ltd., Kingswood, Surrey. This machine, which has been designed primarily for boring holes for telegraph poles, is hydraulically operated, a small pump driven from the tractor power take-off delivering 14 gallons of oil a minute at 2000 lb per square inch to a relief valve, control valve and hydraulic motor. The motor drives a rotary cutting blade, which, it is claimed, will make an 18in diameter hole 6ft deep in about twelve minutes. The cutter is lowered to work by a ram, and when 1ft of earth has been cut the rotary motion is stopped and the soil lifted to the surface, a procedure which is repeated until the full depth has been reached. There was also demonstrated a tractor-roller assembly, which is built by E. V. Twose, Ltd., Lowman Works, Tiverton, Devon. This assembly, which was described and illustrated in THE ENGINEER of April 17, 1953, is a combination of a Ferguson tractor and a small road roller. The tractor is driven up a ramp on to the roller chassis and is then jacked up by its hydraulic lift so that its rear wheels are clear of the roller frame. The drive is taken from the rear wheels of the tractor by heavy-duty chain to the rear roller, and the front roller is chain steered, the steering column being dropped into position through the steering wheel of the tractor. The weight of the combined assembly is 2½ tons.



Ring Stowage, Cruciform Lid, Timing Mechanism and Burning Mixture Can



Smoke Bomb After Ignition

Delayed Action Insecticidal Smoke Bomb

AN INSECTICIDAL smoke generator for use against the tsetse fly in East and Central Africa is being developed for the Ministry of Supply and the Colonial Office by Tiltman Langley Laboratories, Ltd., of Redhill, Surrey. The generators are to be distributed, using a carpet bombing technique, from aircraft flying at about 400ft and will generate their insecticidal smoke at a predetermined time when atmospheric conditions are most favourable for complete coverage of the selected area.

The tsetse fly, carrier of trypanosomiasis (sleeping sickness), has laid barren about 4,000,000 square miles of potential fertile agricultural land in Central and East Africa. The whole of Central Africa, from coast to coast, between latitude 10 deg. N. (the southern edge of the Sahara Desert) and latitude 20 deg. S. (mid-Southern Rhodesia) is infected.

Medical science is providing some protection against the onslaught of this disease—which attacks both man and his domestic animals—and research is continuing into the properties of the drug antrycide (methyl sulphate) and dimidium bromide. However, the effective distribution of an insecticide to clear the disease-carrying fly from this vast tract of territory will form part of an overall campaign that may eventually open up this country which includes French, Belgian and Portuguese possessions.

The unit illustrated, as originally designed, includes a sheet metal container with two compartments, one holding the burning mixture, the other containing a clockwork timing mechanism which can be set for any period of time up to fourteen hours. It is supported from a 21in diameter parachute which allows the container to fall at approximately 50ft per second.

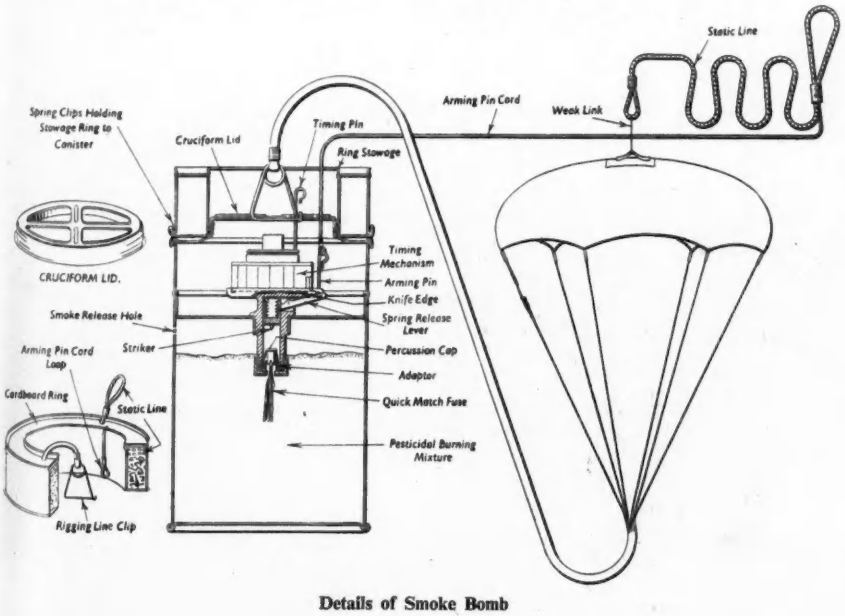
The ignition device consists of a percussion cap and quick match fuse set off by a striker, which is released by the timing mechanism.

Assembly.—The canister is filled with 5 lb of the burning mixture (benzyl hexachloride, D.D.T., or a similar insecticide). The spring-loaded striker is pushed into the body of the timing mechanism and retained by the spring release lever which is in turn locked by the arming pin. The percussion cap, fuse and adaptor (supplied as a unit) are inserted into the barrel of the timing mechanism and are held by the screwed retaining cap.

The timing mechanism is set to a predetermined delay period by turning a graded ring to bring the required hour line opposite the knife edge of the spring release lever. This mechanism is next inserted into the rolled thread in the canister. The cruciform lid is then screwed on and the timing pin inserted into the top of the timing piece to arrest the clock mechanism.

The parachute is placed in the ring stowage and the static line attached. This unit is then attached to the canister with three spring clips and the free loop of the arming pin cord is hooked round the arming pin.

Operation.—For large-scale distribution the canisters would be carried on racks fitted into an aircraft, and fed manually on to a conveyor belt feeding to a hole in the floor of the aircraft. The timing mechanism would be set and the pins removed prior to taking-off. The canisters would be dropped from about 400ft with the aircraft flying at 120–200 m.p.h. In this way



Details of Smoke Bomb

approximately 1285 canisters could be distributed over 12 square miles of territory in one-and-a-quarter hours. This "bombing pattern" could, however, be varied to suit local conditions.

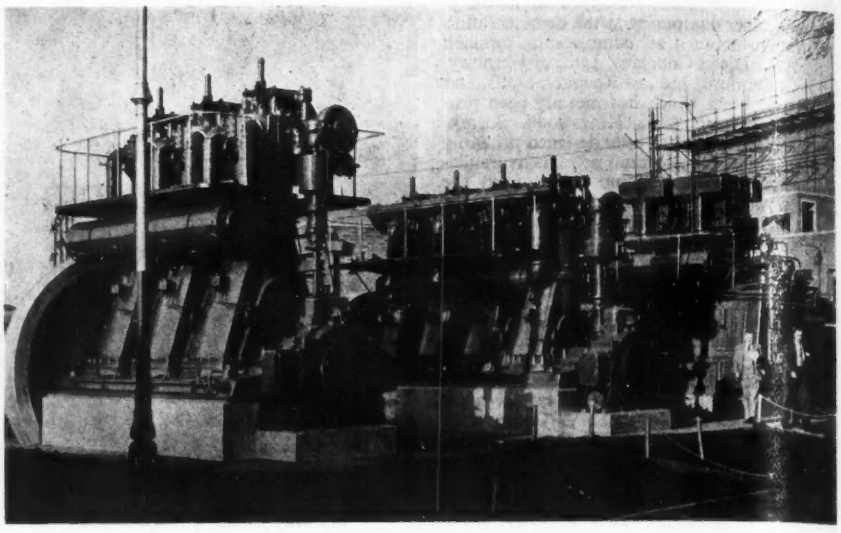
Drastic measures which are already being taken to exterminate the tsetse fly include the destruction of game to break the chain of infection and the clearing of areas of forest, to destroy the insects' breeding grounds. These methods have, however, obvious disadvantages.

The killing of game—apart from sentimental considerations—might well upset the course of nature, while forest clearance could lead to widespread soil erosion.

The practice of area spraying which is being carried out in some districts is not altogether practicable as it depends to a great extent upon favourable meteorological conditions.

The method shown in action in our last illustration has been evolved to overcome all these disadvantages.

Also associated in the production of the new smoke generator are: I.C.I., Ltd., Lea Bridge Industries, Ltd., The Metal Box Co., Ltd., and Smiths English Clocks, Ltd.



Three Veteran Engines in Outdoor Museum

Visit to an Oil Engine Works

LAST week we were able to pay a brief visit to the Rugby Works of the English Electric Company, Ltd., during which there was a tour of the shops to see some of the work in progress. The opportunity was also taken to visit the research department and note the various engines under test.

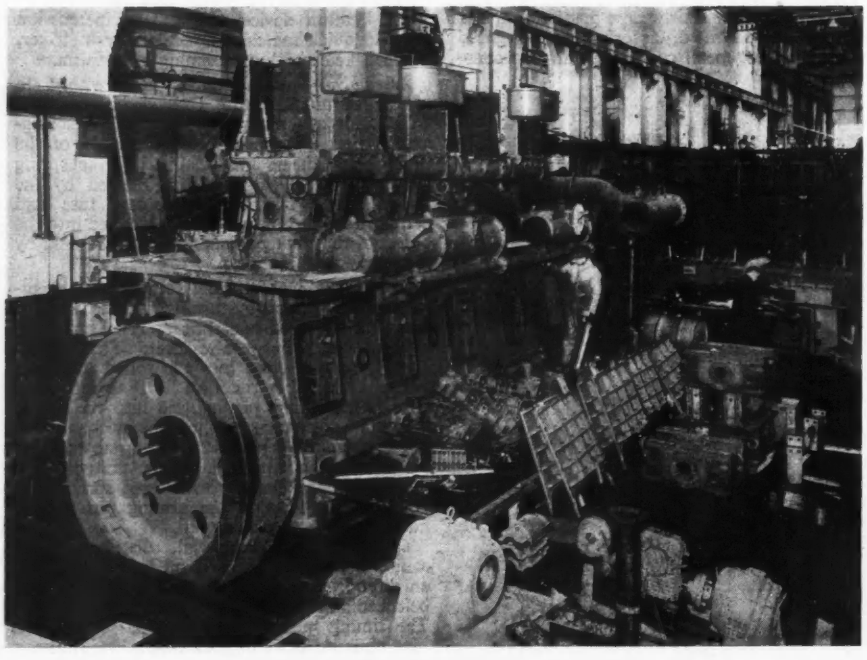
A number of diesel and dual-fuel engines were in different stages of construction in the main assembly bay. These included engines from the company's Mark S.R.L. group, most of them being five-cylinder units for driving alternators and destined for service abroad. At a later date these engines are to burn boiler oil and for this purpose provision has been made for the installation of the necessary equipment such as purifiers, clarifiers and heated fuel circuits. Some examples of seven-cylinder engines were also on view, one of which, rated to develop 1312 b.h.p. at 375 r.p.m., formed the power unit for an alternator generating at 11kV and intended for service in Zanzibar. The new unit is intended to augment the supply from the existing power station, which at present includes in its power plant four "A" frame engines, manufactured by Willans and Robinson, at Rugby, in the early part of this century, and a Mark 4Q Fullagar engine. An example of a dual-fuel engine was a Mark 8R.L.D. unit, having a bore of 15in by 20in stroke, developing 1100 b.h.p. at 428 r.p.m., and due for delivery to the power station at the Point of Ayr Colliery in North Wales. The first of these engines, which will use methane gas emitted from the coal seams as fuel, was shown at the Engineering, Marine and Welding Exhibition last year, and briefly described and illustrated in THE ENGINEER of September 25, 1953.

One engine of interest seen on one of the test beds was an eight-cylinder model "Q" Fullagar engine, which can be seen in our illustration and is the last of four such units ordered by the British Admiralty for service in an overseas dockyard power station. Actually, the company has decided to discontinue the production of this design of engine and so the engine on view was the last which will be built at the Rugby works. The decision ends a period of thirty-four years during which this engine has formed one of the range of diesel engines produced by the company, for it was in 1920 that the licence and drawings of the two-stroke, opposed-piston engine, designed by Dr. Fullagar, were acquired.

The engines, which had a bore and stroke of 14in and 16in respectively, were given the letter "Q" and incorporated air-blast injection of fuel until 1934, when mechanical fuel injection was adopted and greater efficiency attained by the elimination of the reciprocal compressor unit which absorbed about 10 per cent of the engine output. In 1929 the company introduced a larger model of the Fullagar engine which was identified by the suffix letter "R" and had a cylinder diameter of 19in by 22in stroke. Six-cylinder engines of this design were built having an output of 2450 b.h.p. at 200 r.p.m., and later eight-cylinder models were constructed having a rating of 3275 b.h.p. at 200 r.p.m. The first engine manufactured at Rugby was a four-cylinder model "Q" unit developing 750 b.h.p. at 250 r.p.m., and this engine, which on initial trials ran twenty-one days on full load, eventually completed 70,000 hours of operational life before being retired to form part of an outdoor museum.

As already noted the engine was rated at 750 b.h.p. at 250 r.p.m., and had a bore of 14in by 32in combined stroke and weighed 66 tons. It was built in 1921, the patent being purchased from Cammell Laird and Co., Ltd., a company which had developed the engine for marine propulsion purposes and later installed four four-cylinder engines in the diesel-electric fruit carrier "La Playa." Two other engines are included in the outdoor museum, which can be seen in our illustration. One of the engines, which has three cylinders of 20·1in bore by 28·38in stroke, was built in 1912, weighs 67 tons, and had an output of 480 b.h.p. at 187 r.p.m. The second unit, manufactured in 1917 and weighing 59 tons, has four cylinders having a bore and stroke of 19·7in by 24in and developing 500 b.h.p. at 200 r.p.m. All three engines were employed in the works power-house until 1950, and together they have an aggregate operating period approaching 300,000 hours.

In the research and development bay investigations were proceeding on a number of projects, including dual-fuel and gas development, for which purpose a Mark 4R.K.D., 10in bore by 12in stroke engine and a model 5R.L.D. engine, having a bore and stroke of 15in by 20in, were being used. Research work on multi-cylinder turbo-charging is in hand using a Mark 16S.V. unit which is a vee engine having a 10in bore by 12in stroke, and for long endurance tests a twelve-cylinder engine of the same mark is employed. Most of the engines used for research work are fully instrumented on a permanent basis and the equipment is the responsibility of a special instrument section which undertakes the development and maintenance of all the instrumentation required throughout the works.



Admiralty 8Q Fullagar Engine Nearing Completion

GROSS TONNAGE OF "ARCADIA" AND "IBERIA."—We are informed that the gross tonnage of the new P. and O. liner "Arcadia" is 29,734 tons, and that her sister ship, "Iberia," launched last week from the yard of Harland and Wolff, Ltd., will have a gross tonnage of about 29,500 tons.

DIAGRAMMATIC ARRANGEMENT OF 10-TON DERRICK CRANE.

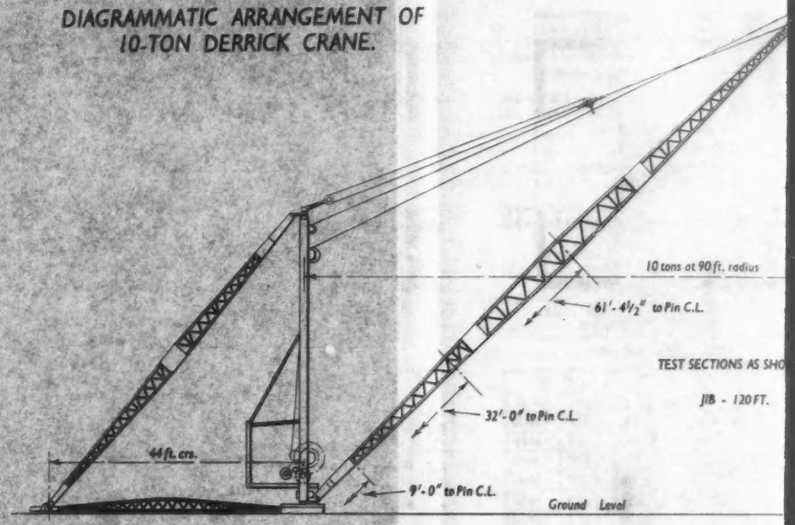


Fig. 1

LAYOUT OF GAUGES.

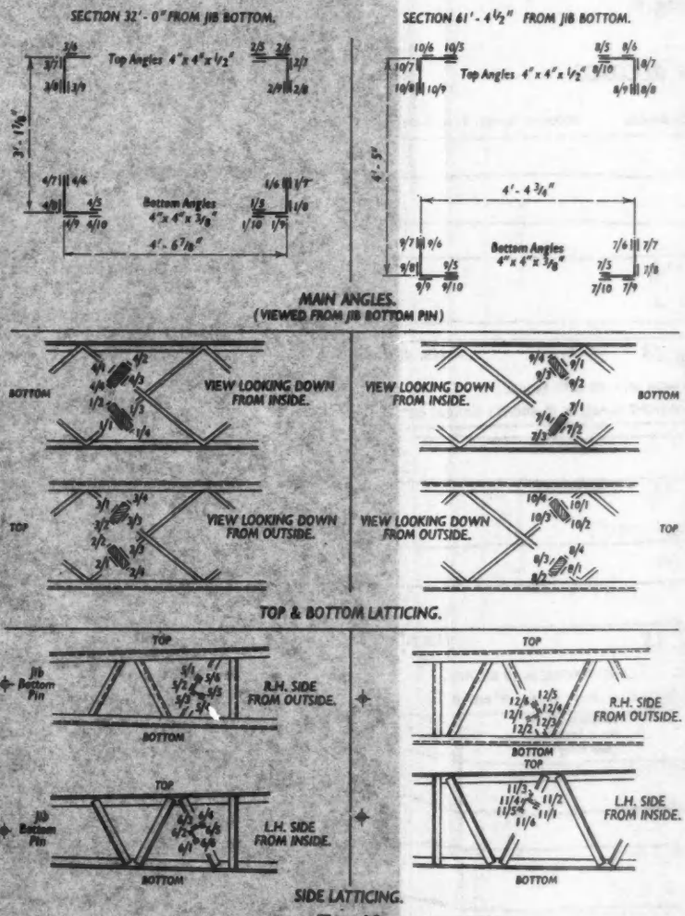

SECTION 32'-0" FROM JIB BOTTOM.
SECTION 61'-4½" FROM JIB BOTTOM.
Top Angles 4" x 4" x ½"
Bottom Angles 4" x 4" x ⅜"
4'-6 7/16"
4'-4 3/16"
MAIN ANGLES.
(VIEWED FROM JIB BOTTOM PIN)
VIEW LOOKING DOWN FROM INSIDE.
VIEW LOOKING DOWN FROM OUTSIDE.
TOP & BOTTOM LATTICING.
R.H. SIDE FROM OUTSIDE.
L.H. SIDE FROM INSIDE.
SIDE LATTICING.

Fig. 10

DIAGRAMMATIC ARRANGEMENT OF 10-TON DERRICK CRANE.

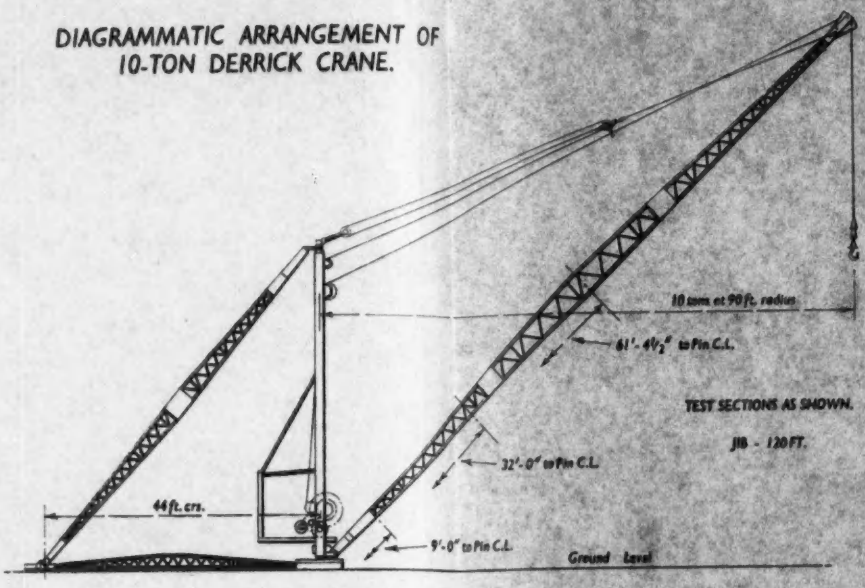


Fig. 1

LAYOUT OF GAUGES.

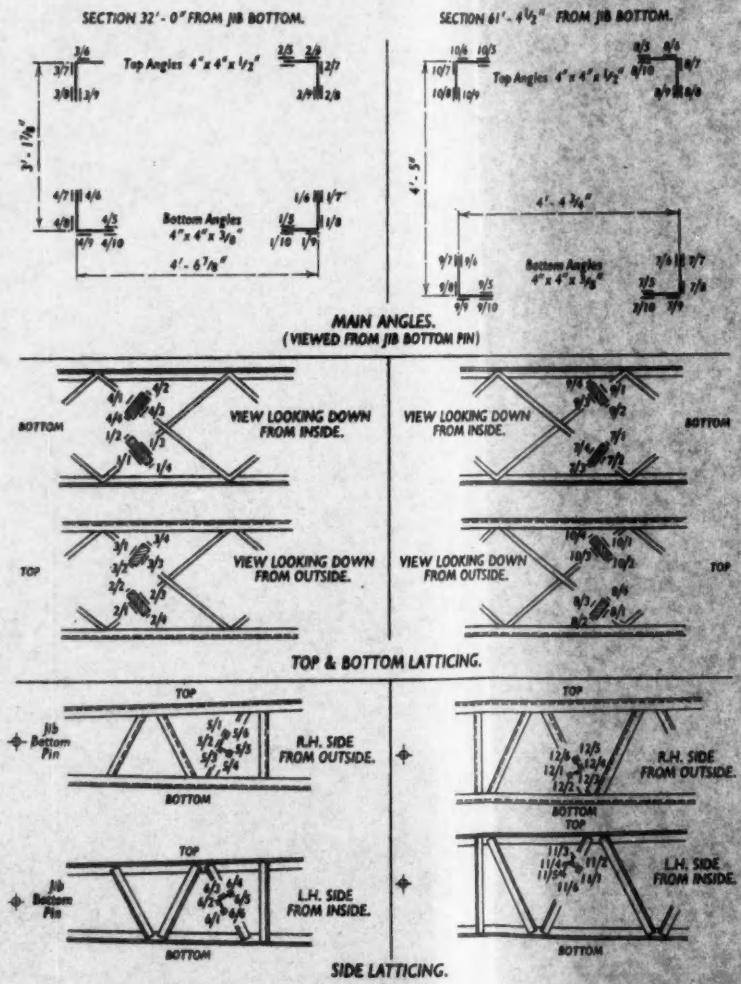


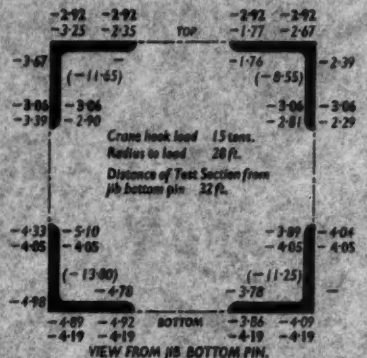
Fig. 10

STRESSES IN THE JIB OF A 10-TON

STAT

COMPARISON OF EXPERIMENTA

EXPERIMENTAL VALUES SHOWN THUS:- 0·00 CALCULATED VALUES SHOWN THUS:- 0·00

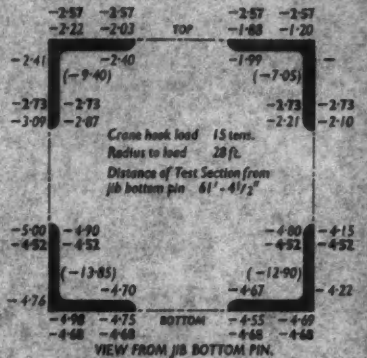


VIEW FROM JIB BOTTOM PIN.

FLANGE LOAD COMPARISON.

	ITEM		Load - Tons Exp'tl.	Calc'd
P_1	Total Flange Load All Effects	Top	-20·3	-21·70
		Bottom	-25·0	-22·30
P_2	Direct (including jib weight effect)	Top	-25·7	-25·00
		Bottom	-19·6	-19·00
P_3	Bending (Due to jib weight only)	Top	- 4·9	- 5·60
		Bottom	+ 4·9	+ 5·60
P_4	Bending (Due to eccentricity of thrust)	Top	+10·4	+ 8·86
		Bottom	-10·4	- 8·86
	Load Taken by Latticing		Negligible	
	Total Direct Load on Section		-45·3	-44·00

Fig. 2

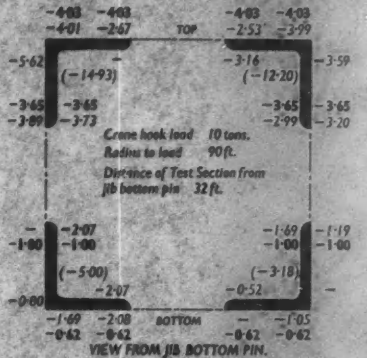


VIEW FROM JIB BOTTOM PIN.

FLANGE LOAD COMPARISON.

	ITEM		Load - Tons Exp'tl.	Calc'd.
P_1	Total Flange Load All Effects	Top	-16·4	-18·90
		Bottom	-26·8	-25·10
P_2	Direct (including jib weight effect)	Top	-24·5	-25·00
		Bottom	-18·7	-19·00
P_3	Bending (Due to jib weight only)	Top	- 4·2	- 4·42
		Bottom	+ 4·2	+ 4·42
P_4	Bending (Due to eccentricity of thrust)	Top	+12·3	+10·50
		Bottom	-12·3	-10·50
	Load Taken by Latticing		Negligible	
	Total Direct Load on Section		-43·2	-44·00

Fig. 3

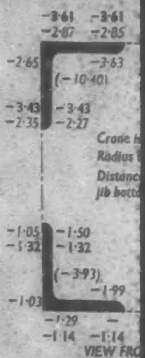


VIEW FROM JIB BOTTOM PIN.

FLANGE LOAD COMPARISON.

	ITEM		Load - Tons Exp'd.	Calc'd.
P_1	Total Flange Load All Effects	Top	-27·1	-30·00
		Bottom	- 8·2	- 3·50
P_2	Direct (Including jib weight effect)	Top	-20·0	-18·90
		Bottom	-15·3	-14·60
P_3	Bending (Due to jib weight only)	Top	-15·5	-18·30
		Bottom	+15·5	+18·30
P_4	Bending (Due to eccentricity of thrust)	Top	+ 8·4	+ 7·20
		Bottom	- 8·4	- 7·20
	Load Taken by Latticing		Negligible	
	Total Direct Load on Section		-35·3	-33·50

Fig. 4



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FLANGE L

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P_1	Total Flange Lo All Effects		
P_2	Direct (Includin weight effect		
P_3	Bending (Due to weight only)		
P_4	Bending (Due eccentricity of th		
	Load Taken by Lat		
	Total Direct Lo on Section		

XPERIMENTALLY RECORDED VALUES OF LOADS CARRIED BY MAIN ANGLES.

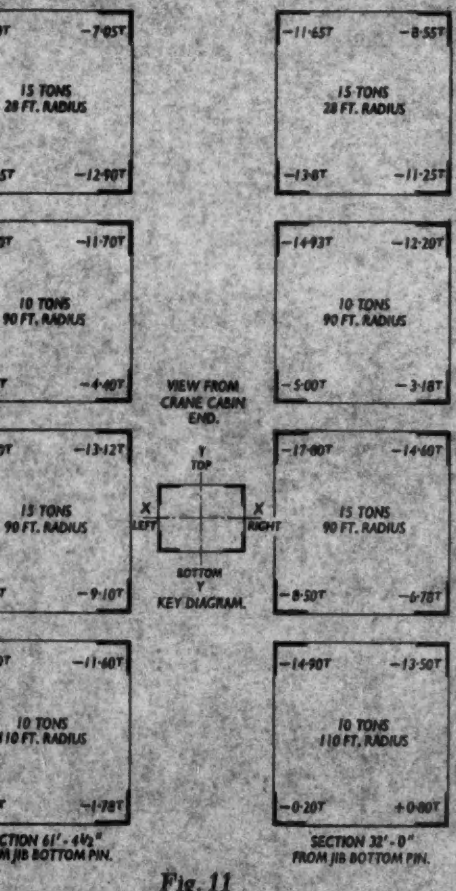


Fig. 11

SPECIMEN RECORDS.

LOWERING 5 TONS LOAD AT 126 f.p.m. AT 90 FT. RADIUS. BROUGHT TO REST IN 5·75 INS.

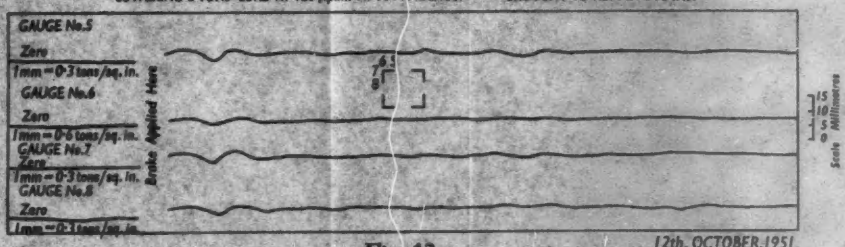


Fig. 12

12th. OCTOBER, 1951.

LOWERING 10 TONS LOAD AT 48 f.p.m. AT 20 FT. RADIUS. BROUGHT TO REST IN 4·5 INS.

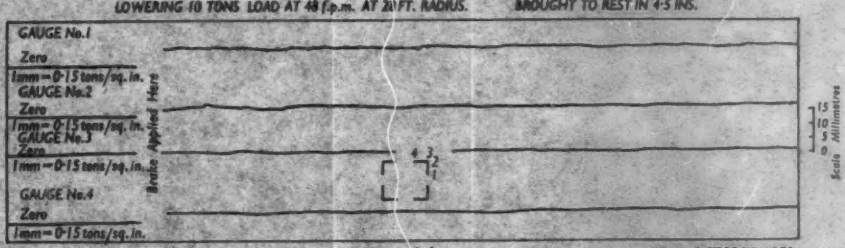


Fig. 14

11th. OCTOBER, 1951.

SLEWING 10 TONS AT 90 FT. RADIUS. 45° TRAVERSE IN 6·7 SECONDS.

DISTANCE TO REST AFTER BRAKING 6' - 3" AT 16' - 10" RADIUS.

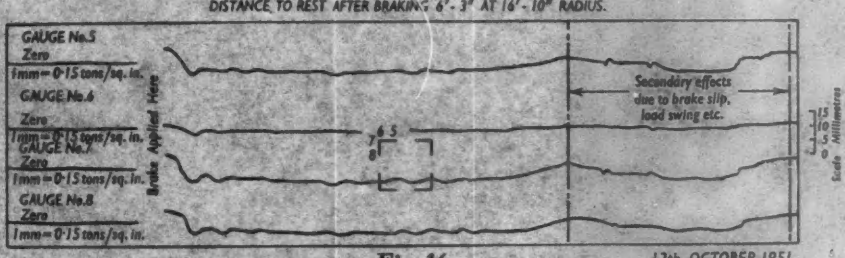
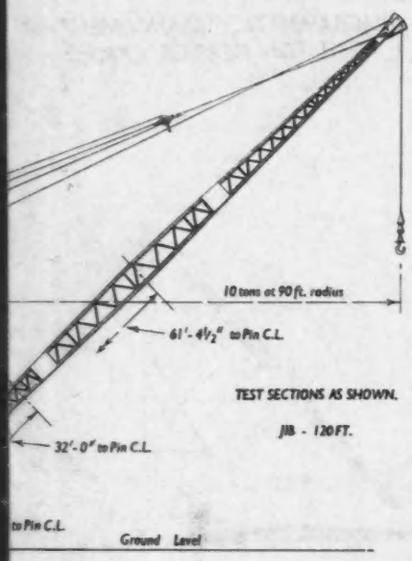


Fig. 16

12th. OCTOBER, 1951.

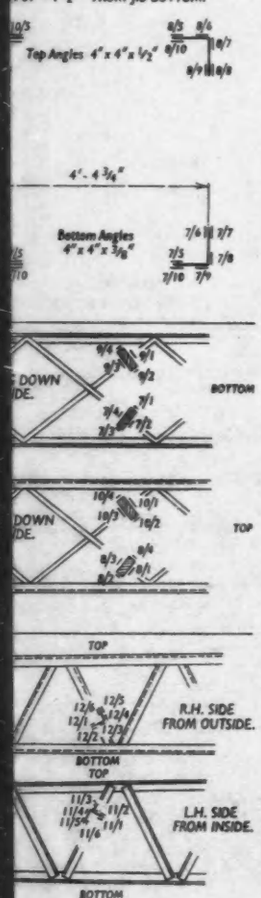
STRESSES IN THE JIB OF A 10-T

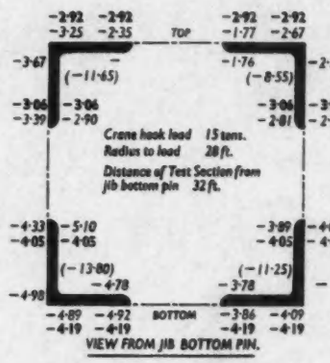


g. 1

S.

N 61'-4½" FROM JIB BOTTOM.

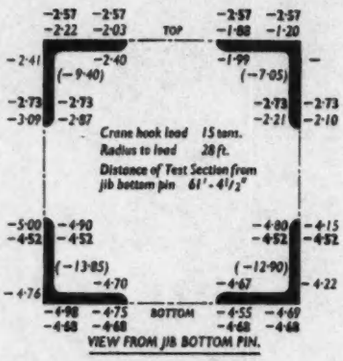



TOP
BOTTOM
Crane hook load 15 tons.
Radius to load 28 ft.
Distance of Test Section from jib bottom pin 32 ft.
VIEW FROM JIB BOTTOM PIN.

FLANGE LOAD COMPARISON.

	ITEM		Load - Tons Exp'tl.	Load - Tons Calc'd
P_1	Total Flange Load All Effects	Top	−20·3	−21·70
		Bottom	−25·0	−22·30
P_2	Direct (Including jib weight effect)	Top	−25·7	−25·00
		Bottom	−19·6	−19·00
P_3	Bending (Due to jib weight only)	Top	− 4·9	− 5·60
		Bottom	+ 4·9	+ 5·60
P_4	Bending (Due to eccentricity of thrust)	Top	+10·4	+ 8·86
		Bottom	−10·4	− 8·86
	Load Taken by Latticing		Negligible	
	Total Direct Load on Section		−45·3	−44·00

Fig. 2


TOP
BOTTOM
Crane hook load 15 tons.
Radius to load 28 ft.
Distance of Test Section from jib bottom pin 61'-4½"
VIEW FROM JIB BOTTOM PIN.

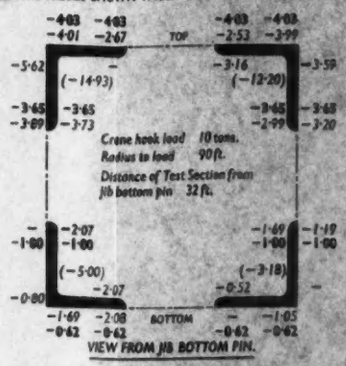
FLANGE LOAD COMPARISON.

	ITEM		Load - Tons Exp'tl.	Load - Tons Calc'd.
P_1	Total Flange Load All Effects	Top	− 16·4	−18·90
		Bottom	− 26·8	−25·10
P_2	Direct (Including jib weight effect)	Top	−24·5	−25·00
		Bottom	−18·7	−19·00
P_3	Bending (Due to jib weight only)	Top	− 4·2	− 4·42
		Bottom	+ 4·2	+ 4·42
P_4	Bending (Due to eccentricity of thrust)	Top	+12·3	+10·58
		Bottom	−12·3	−10·58
	Load Taken by Latticing		Negligible	
	Total Direct Load on Section		−43·2	−44·00

Fig. 3

COMPARISON OF EX

EXPERIMENTAL VALUES SHOWN THUS:- 0·00 CALCULATED VALUES SHOWN


TOP
BOTTOM
Crane hook load 10 tons.
Radius to load 90 ft.
Distance of Test Section from jib bottom pin 32 ft.
VIEW FROM JIB BOTTOM PIN.

FLANGE LOAD COMPARISON.

	ITEM		Load - Tons Exp'tl.	Load - Tons Calc'd.
P_1	Total Flange Load All Effects	Top	−27·1	−29·00
		Bottom	− 8·2	− 3·50
P_2	Direct (Including jib weight effect)	Top	−20·0	−18·98
		Bottom	−15·3	−14·60
P_3	Bending (Due to jib weight only)	Top	−15·5	−18·38
		Bottom	+15·5	+18·38
P_4	Bending (Due to eccentricity of thrust)	Top	+ 8·4	+ 7·20
		Bottom	− 8·4	− 7·20
	Load Taken by Latticing		Negligible	
	Total Direct Load on Section		− 35·3	−33·38

Fig. 4

EXPERIMENTALLY RECORDED VALUES OF LOADS CARRIED BY MAIN ANGLES.

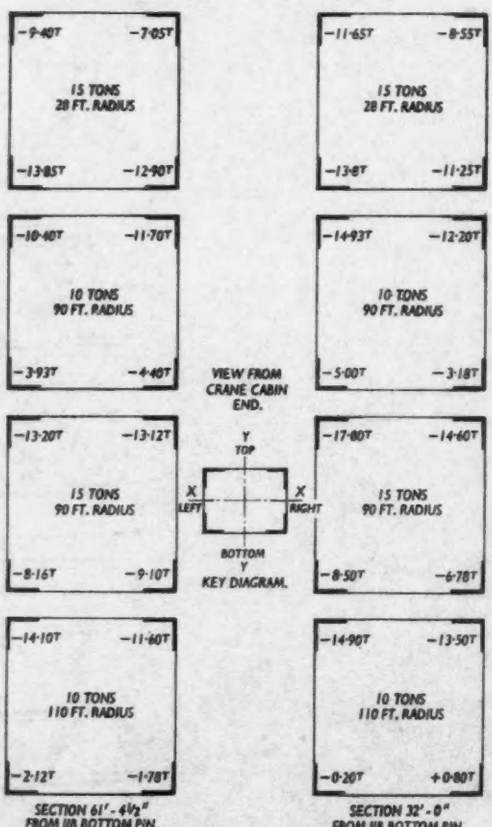


Fig. 11

SPECIMEN RECORDS.

LOWERING 5 TONS LOAD AT 126 f.p.m. AT 90 FT. RADIUS. BROUGHT TO REST IN 5·75 INS.

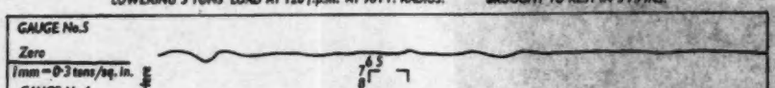


Fig. 12

12th. OCTOBER, 1951.

LOWERING 10 TONS LOAD AT 48 f.p.m. AT 28 FT. RADIUS. BROUGHT TO REST IN 4·5 INS.

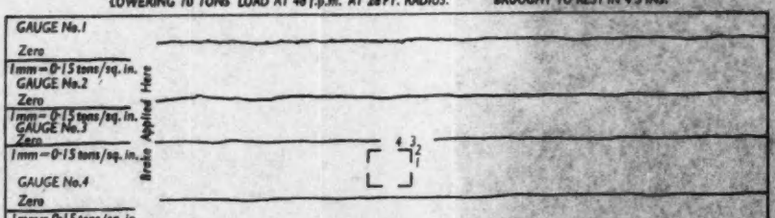


Fig. 14

11th. OCTOBER, 1951.

SLEWING 10 TONS AT 90 FT. RADIUS. 45° TRAVERSE IN 6·7 SECONDS.

DISTANCE TO REST AFTER BRAKING 6'-3" AT 16'-10" RADIUS.

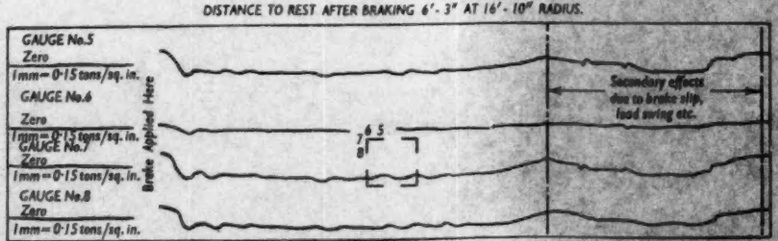


Fig. 16

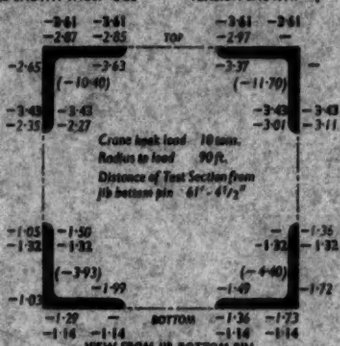
12th. OCTOBER, 1951.

-TON DERRICK CRANE

STATIC TEST OF 10-TON DERRICK CRANE.

N OF EXPERIMENTAL AND CALCULATED TOTAL STRESS VALUES (TONS/IN.^{2}) AND AVERAGE FLANGE LOADS (TONS).

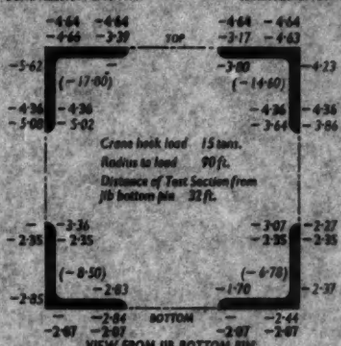
ES SHOWN THUS:- 0·00 TENSION SHOWN:- + COMPRESSION SHOWN:- − STRESSES GIVEN ON ANGLES. LOADS ON INDIVIDUAL ANGLES SHOWN THUS:- (0·00)


Crane hook load 10 tons.
Radius to load 90 ft.
Distance of Test Section from jib bottom pin 61' - 4½"
TOP
BOTTOM
VIEW FROM JIB BOTTOM PIN.

FLANGE LOAD COMPARISON.

	ITEM		Load - Tons Exp'td.	Load - Tons Calc'd.
P_1	Total Flange Load All Effects	Top	−22·1	−26·70
		Bottom	− 8·33	− 6·00
P_2	Direct (including jib weight effect)	Top	−17·3	−19·00
		Bottom	−13·1	−14·50
P_3	Bending (Due to jib weight only)	Top	−12·9	−15·00
		Bottom	+12·9	+15·00
P_4	Bending (Due to eccentricity of thrust)	Top	+ 8·1	+ 8·10
		Bottom	− 8·1	− 8·10
	Load Taken by Latticing		Negligible	
	Total Direct Load on Section		−30·4	−38·58

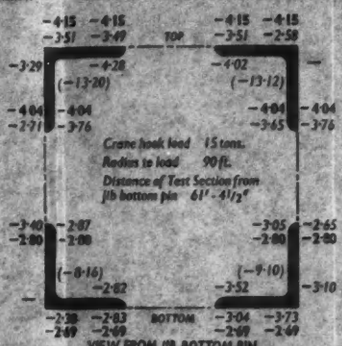
Fig. 5


Crane hook load 15 tons.
Radius to load 90 ft.
Distance of Test Section from jib bottom pin 32 ft.
TOP
BOTTOM
VIEW FROM JIB BOTTOM PIN.

FLANGE LOAD COMPARISON.

	ITEM		Load - Tons Exp'td.	Load - Tons Calc'd.
P_1	Total Flange Load All Effects	Top	−32·4	−34·70
		Bottom	−15·3	−11·00
P_2	Direct (including jib weight effect)	Top	−27·0	−26·20
		Bottom	−20·7	−20·20
P_3	Bending (Due to jib weight only)	Top	−15·5	−18·20
		Bottom	+15·5	+18·30
P_4	Bending (Due to eccentricity of thrust)	Top	+10·1	+ 9·83
		Bottom	−10·1	− 9·83
	Load Taken by Latticing		Negligible	
	Total Direct Load on Section		−47·7	−46·50

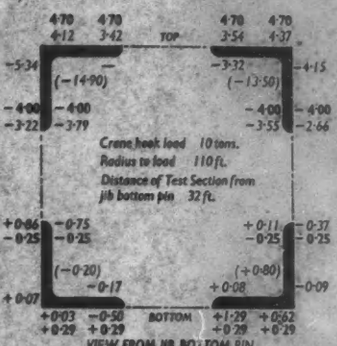
Fig. 6


Crane hook load 15 tons.
Radius to load 90 ft.
Distance of Test Section from jib bottom pin 61' - 4½"
TOP
BOTTOM
VIEW FROM JIB BOTTOM PIN.

FLANGE LOAD COMPARISON.

	ITEM		Load - Tons Exp'td.	Load - Tons Calc'd.
P_1	Total Flange Load All Effects	Top	−26·3	−31·10
		Bottom	−17·3	−15·40
P_2	Direct (including jib weight effect)	Top	−24·7	−26·40
		Bottom	−18·9	−20·10
P_3	Bending (Due to jib weight only)	Top	−13·0	−15·00
		Bottom	+13·0	+15·00
P_4	Bending (Due to eccentricity of thrust)	Top	+11·4	+11·10
		Bottom	−11·4	−11·10
	Load Taken by Latticing		Negligible	
	Total Direct Load on Section		−43·6	−46·50

Fig. 7


Crane hook load 10 tons.
Radius to load 110 ft.
Distance of Test Section from jib bottom pin 32 ft.
TOP
BOTTOM
VIEW FROM JIB BOTTOM PIN.

FLANGE LOAD COMPARISON.

	ITEM		Load - Tons Exp'td.	Load - Tons Calc'd.
P_1	Total Flange Load All Effects	Top	− 28·4	−34·00
		Bottom	+ 0·6	+ 1·00
P_2	Direct (including jib weight effect)	Top	−16·4	−18·70
		Bottom	−12·6	−14·30
P_3	Bending (Due to jib weight only)	Top	−18·8	−22·00
		Bottom	+18·8	+22·00
P_4	Bending (Due to eccentricity of thrust)	Top	+ 6·8	+ 6·65
		Bottom	− 6·8	− 6·65
	Load Taken by Latticing		Negligible	
	Total Direct Load on Section		−29·0	−33·00

Fig. 8

SPECIMEN RECORDS.

LOWERING 10 TONS LOAD AT 48 f.p.m. AT 90 FT. RADIUS. BROUGHT TO REST IN 10·25 INS.

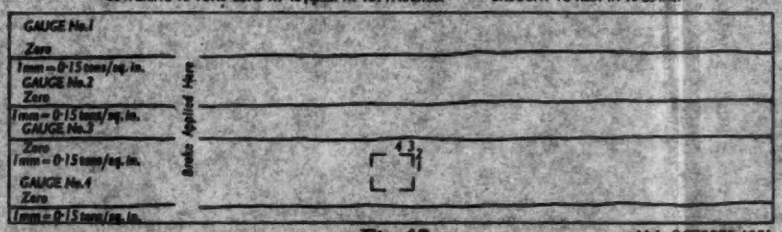


Fig. 13 11th. OCTOBER, 1951.

DERRICKING 10 TONS LOAD FROM 28 FT. TO 90 FT. RADIUS.
DERRICKED THROUGH 10° IN 10·3 SECONDS. BROUGHT TO REST IN 10 MINUTES ANGULAR DISTANCE.

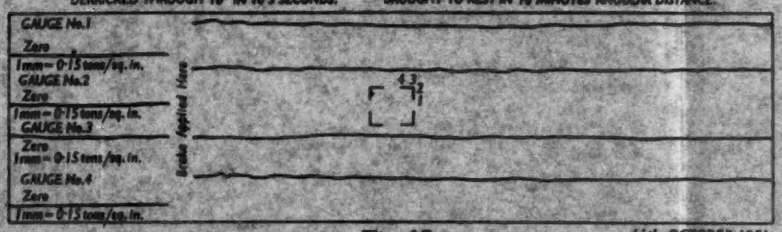


Fig. 15 11th. OCTOBER, 1951.

SLEWING 10 TONS LOAD AT 110 FT. RADIUS. 45° TRAVERSE IN 8·2 SECONDS.
DISTANCE TO REST AFTER APPLICATION OF BRAKE 6'- 0½" AT 16'- 10" RADIUS.

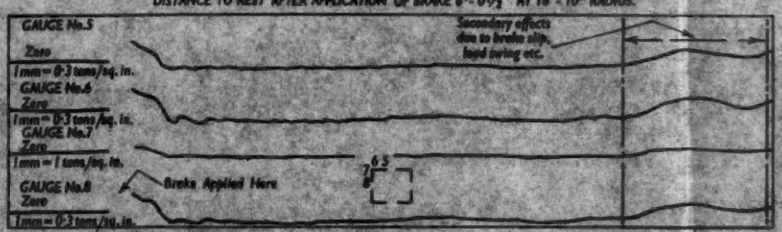


Fig. 17 12th. OCTOBER, 1951.

DYNAMIC TEST.

- SLEWING -

MAXIMUM AND MINIMUM TOTAL STRESS VALUES IN TO

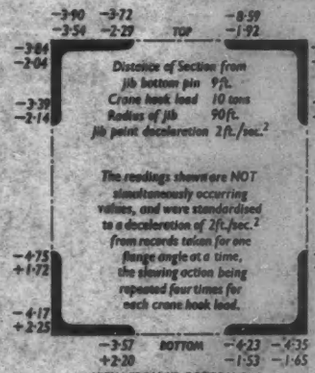

Distance of Section from jib bottom pin 9 ft.
Crane hook load 10 tons
Radius of jib 90 ft.
Jib point deceleration 2 ft./sec.^{2}
The readings shown are NOT simultaneously occurring values, and were standardised to a deceleration of 2 ft./sec.^{2} from records taken for one flange angle at a time, the slewing action being repeated four times for each crane hook load.
TOP
BOTTOM
VIEW FROM JIB BOTTOM PIN.

Fig. 18

FORCE ANALYSIS FOR DERRICK CRANE.

LOAD 10 TONS AT A JIB RADIUS OF 90 FT.

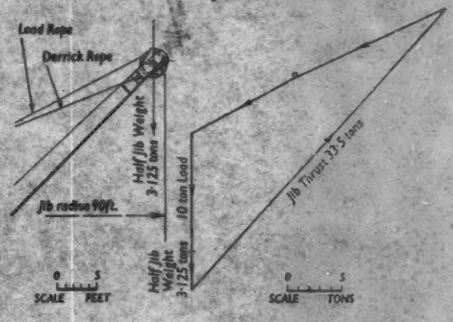


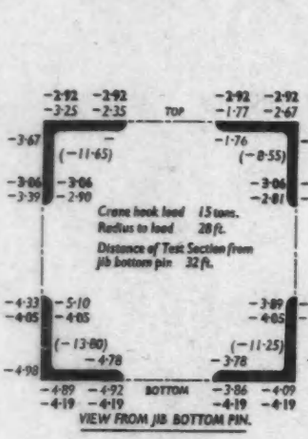
Fig. 20

STRESSES IN THE JIB OF A 10-TON DERRICK

STATIC TEST OF 10-TON

COMPARISON OF EXPERIMENTAL AND CALCULATED TOTAL STRESS V

EXPERIMENTAL VALUES SHOWN THUS:- 0·00 CALCULATED VALUES SHOWN THUS:- 0·00 TENSION SHOWN:- +

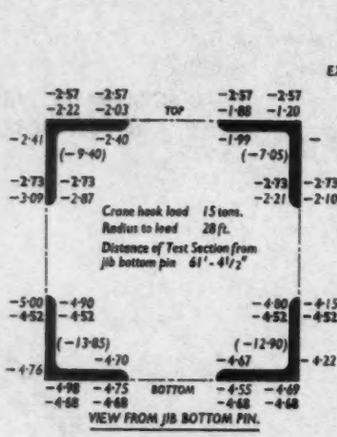


VIEW FROM JIB BOTTOM PIN.

FLANGE LOAD COMPARISON.

	ITEM		Load - Tons Exp'tl.	Load - Tons Calc'd
P_1	Total Flange Load All Effects	Top	−20·3	−21·70
		Bottom	−25·0	−22·30
P_2	Direct (Including jib weight effect)	Top	−25·7	−25·00
		Bottom	−19·6	−19·00
P_3	Bending (Due to jib weight only)	Top	− 4·9	− 5·60
		Bottom	+ 4·9	+ 5·60
P_4	Bending (Due to eccentricity of thrust)	Top	+10·4	+ 8·86
		Bottom	−10·4	− 8·86
	Load Taken by Latticing		Negligible	
	Total Direct Load on Section		−45·3	−44·00

Fig. 2

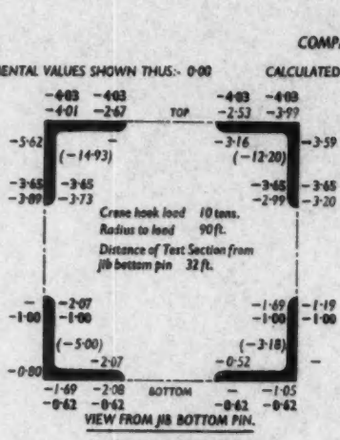


VIEW FROM JIB BOTTOM PIN.

FLANGE LOAD COMPARISON.

	ITEM		Load - Tons Exp'tl.	Load - Tons Calc'd.
P_1	Total Flange Load All Effects	Top	−16·4	−18·90
		Bottom	−26·8	−25·10
P_2	Direct (Including jib weight effect)	Top	−24·5	−25·00
		Bottom	−18·7	−19·00
P_3	Bending (Due to jib weight only)	Top	− 4·2	− 4·42
		Bottom	+ 4·2	+ 4·42
P_4	Bending (Due to eccentricity of thrust)	Top	+12·3	+10·58
		Bottom	−12·3	−10·58
	Load Taken by Latticing		Negligible	
	Total Direct Load on Section		−43·2	−44·00

Fig. 3

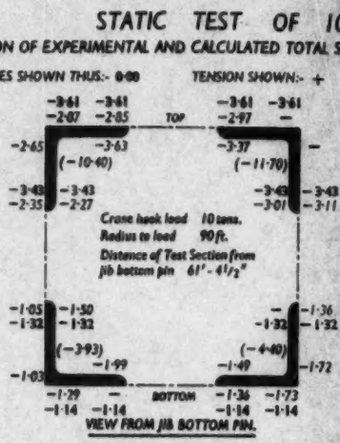


VIEW FROM JIB BOTTOM PIN.

FLANGE LOAD COMPARISON.

	ITEM		Load - Tons Exp'tl.	Load - Tons Calc'd.
P_1	Total Flange Load All Effects	Top	−27·1	−30·00
		Bottom	− 8·2	− 3·50
P_2	Direct (Including jib weight effect)	Top	−20·0	−18·90
		Bottom	−15·3	−14·60
P_3	Bending (Due to jib weight only)	Top	−15·5	−18·30
		Bottom	+15·5	+18·30
P_4	Bending (Due to eccentricity of thrust)	Top	+ 8·4	+ 7·20
		Bottom	− 8·4	− 7·20
	Load Taken by Latticing		Negligible	
	Total Direct Load on Section		−35·3	−33·50

Fig. 4



VIEW FROM JIB BOTTOM PIN.

FLANGE LOAD COMPARISON.

	ITEM		Load - Tons Exp'tl.	Load - Tons Calc'd.
P_1	Total Flange Load All Effects	Top	−22·1	−26·70
		Bottom	− 8·32	− 6·00
P_2	Direct (Including jib weight effect)	Top	−17·3	−19·00
		Bottom	−13·1	−14·50
P_3	Bending (Due to jib weight only)	Top	−12·9	−15·80
		Bottom	+12·9	+15·80
P_4	Bending (Due to eccentricity of thrust)	Top	+ 8·1	+ 8·10
		Bottom	− 8·1	− 8·10
	Load Taken by Latticing		Negligible	
	Total Direct Load on Section		−30·4	−33·50

Fig. 5

EXPERIMENTALLY RECORDED VALUES OF LOADS CARRIED BY MAIN ANGLES.

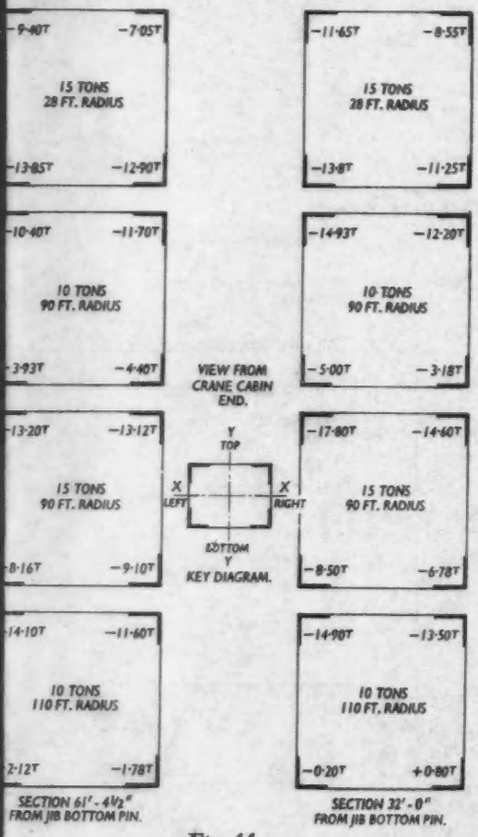


Fig. 11

SPECIMEN RECORDS.

LOWERING 5 TONS LOAD AT 126 f.p.m. AT 90 FT. RADIUS. BROUGHT TO REST IN 5·75 INS.

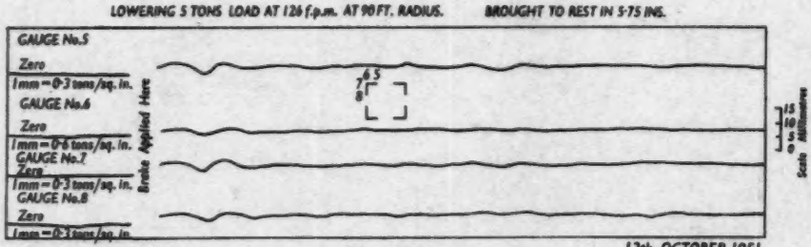


Fig. 12

12th. OCTOBER, 1951.

LOWERING 10 TONS LOAD AT 48 f.p.m. AT 28 FT. RADIUS. BROUGHT TO REST IN 4·5 INS.

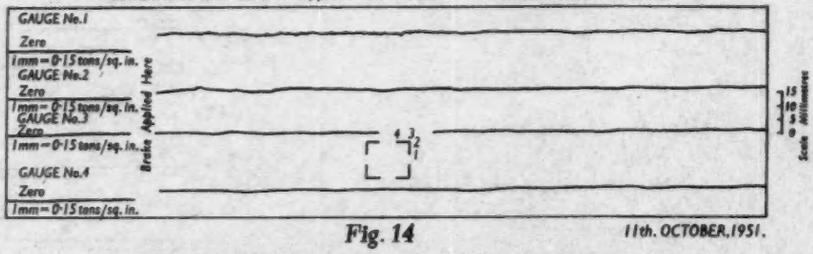


Fig. 14

11th. OCTOBER, 1951.

SLEWING 10 TONS AT 90 FT. RADIUS. 45° TRAVERSE IN 6·7 SECONDS.
DISTANCE TO REST AFTER BRAKING 6'-3" AT 16'-10" RADIUS.

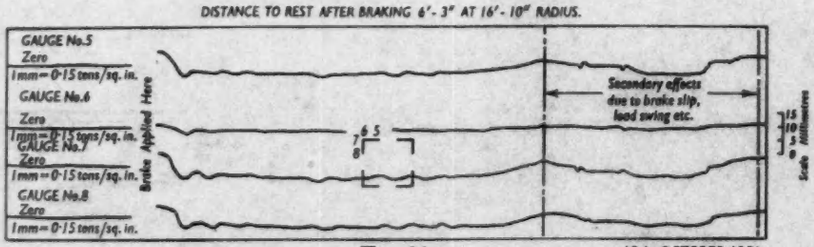
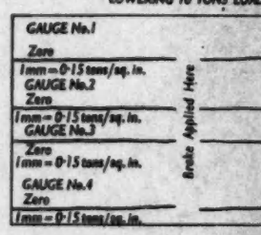


Fig. 16

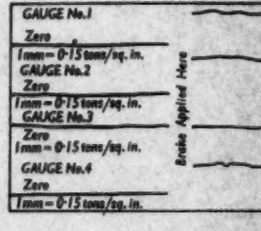
12th. OCTOBER, 1951.

LOWERING 10 TONS LOAD



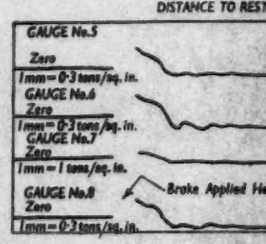
DERRIC

DERRICKED THROUGH 10° IN 1



SLEWING 10 TONS L

DISTANCE TO REST

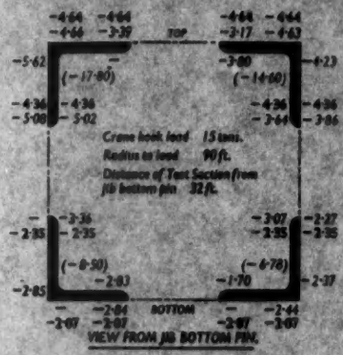


CK CRANE

TON DERRICK CRANE.

RESS VALUES (TONS/IN.²) AND AVERAGE FLANGE LOADS (TONS).

COMPRESSION SHOWN:- — STRESSES GIVEN ON ANGLES. LOADS ON INDIVIDUAL ANGLES SHOWN THUS:- (0·00)

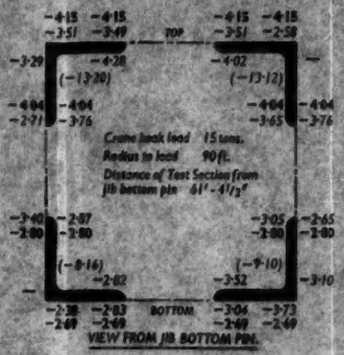


VIEW FROM JIB BOTTOM PIN.

FLANGE LOAD COMPARISON.

	ITEM		Load - Tons Exp'd.	Calc'd.
P_1	Total Flange Load All Effects	Top	−32·4	−34·70
		Bottom	−15·3	−11·00
P_2	Direct (Including jib weight effect)	Top	−27·0	−26·20
		Bottom	−20·7	−20·30
P_3	Bending (Due to jib weight only)	Top	−15·5	−18·90
		Bottom	+15·5	+18·20
P_4	Bending (Due to eccentricity of thrust)	Top	+10·1	+ 9·83
		Bottom	− 10·1	− 9·83
	Load Taken by Latticing		Negligible	
	Total Direct Load on Section		−47·7	−46·90

Fig. 6

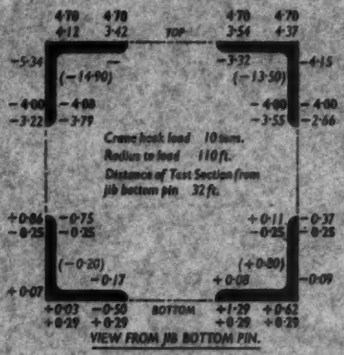


VIEW FROM JIB BOTTOM PIN.

FLANGE LOAD COMPARISON.

	ITEM		Load - Tons Exp'd.	Calc'd.
P_1	Total Flange Load All Effects	Top	−26·3	−31·10
		Bottom	−17·3	−16·40
P_2	Direct (Including jib weight effect)	Top	−24·7	−26·40
		Bottom	−18·9	−20·10
P_3	Bending (Due to jib weight only)	Top	−13·0	−15·80
		Bottom	+13·0	+15·80
P_4	Bending (Due to eccentricity of thrust)	Top	+11·4	+11·10
		Bottom	−11·4	−11·10
	Load Taken by Latticing		Negligible	
	Total Direct Load on Section		− 43·6	−46·50

Fig. 7

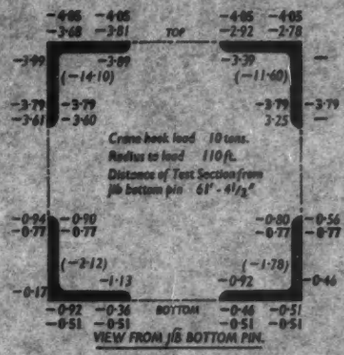


VIEW FROM JIB BOTTOM PIN.

FLANGE LOAD COMPARISON.

	ITEM		Load - Tons Exp'd.	Calc'd.
P_1	Total Flange Load All Effects	Top	− 28·4	−34·00
		Bottom	+ 0·6	+ 1·00
P_2	Direct (Including jib weight effect)	Top	−16·4	−18·70
		Bottom	−12·6	−14·30
P_3	Bending (Due to jib weight only)	Top	− 18·8	−22·00
		Bottom	+ 18·8	+22·00
P_4	Bending (Due to eccentricity of thrust)	Top	+ 6·8	+ 6·65
		Bottom	− 6·8	− 6·65
	Load Taken by Latticing		Negligible	
	Total Direct Load on Section		−29·0	−33·00

Fig. 8



VIEW FROM JIB BOTTOM PIN.

FLANGE LOAD COMPARISON.

	ITEM		Load - Tons Exp'd.	Calc'd.
P_1	Total Flange Load All Effects	Top	−25·7	−29·80
		Bottom	− 3·9	− 3·30
P_2	Direct (Including jib weight effect)	Top	−16·8	−18·70
		Bottom	−12·8	−14·30
P_3	Bending (Due to jib weight only)	Top	−16·1	−19·00
		Bottom	+16·1	+19·00
P_4	Bending (Due to eccentricity of thrust)	Top	+ 7·2	+ 7·95
		Bottom	− 7·2	− 7·95
	Load Taken by Latticing		Negligible	
	Total Direct Load on Section		−29·6	−33·00

Fig. 9

SPECIMEN RECORDS.

...S LOAD AT 48 f.p.m. AT 90 FT. RADIUS. BROUGHT TO REST IN 10·25 INS.

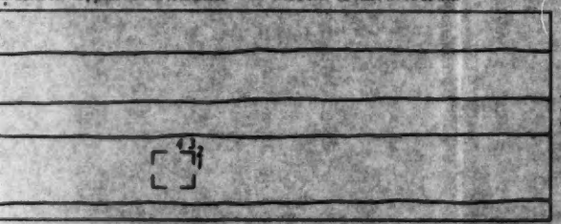


Fig. 13 11th. OCTOBER, 1951.

...DERRICKING 10 TONS LOAD FROM 28 FT. TO 90 FT. RADIUS.

...0° IN 10·3 SECONDS. BROUGHT TO REST IN 10 MINUTES ANGULAR DISTANCE.

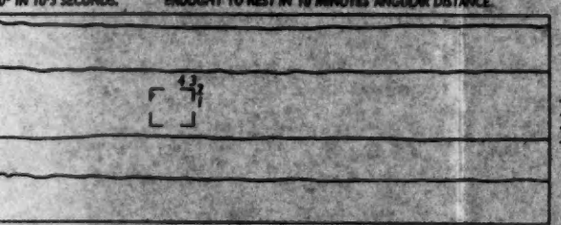


Fig. 15 11th. OCTOBER, 1951.

...TONS LOAD AT 110 FT. RADIUS. 45° TRAVERSE IN 8·2 SECONDS.

...TO REST AFTER APPLICATION OF BRAKE 6'- 0½" AT 16'- 10" RADIUS.

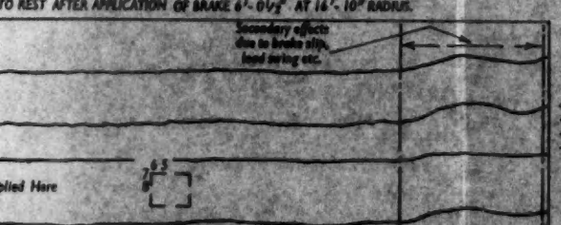
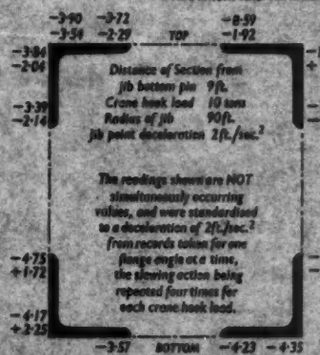


Fig. 17 12th. OCTOBER, 1951.

DYNAMIC TEST.

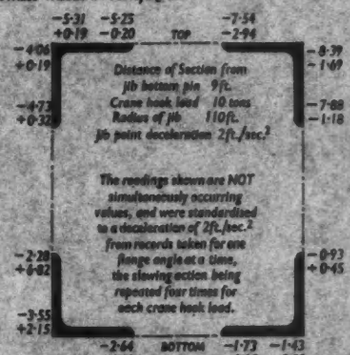
- SLEWING -

MAXIMUM AND MINIMUM TOTAL STRESS VALUES IN TONS/SQ. IN.


Distance of Section from jib bottom pin 9 ft.
Crane hook load 10 tons
Radius of jib 90 ft.
Jib point deceleration 2 ft./sec.²
The readings shown are NOT simultaneously occurring values, and were standardised to a deceleration of 2 ft./sec.² from records taken for one flange angle at a time, the slewing action being repeated four times for each crane hook load.
TOP
BOTTOM

VIEW FROM JIB BOTTOM PIN.

Fig. 18

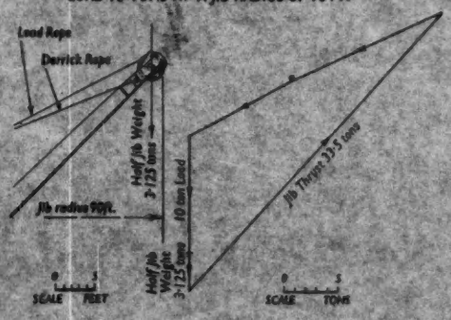

Distance of Section from jib bottom pin 9 ft.
Crane hook load 10 tons
Radius of jib 110 ft.
Jib point deceleration 2 ft./sec.²
The readings shown are NOT simultaneously occurring values, and were standardised to a deceleration of 2 ft./sec.² from records taken for one flange angle at a time, the slewing action being repeated four times for each crane hook load.
TOP
BOTTOM

VIEW FROM JIB BOTTOM PIN.

Fig. 19

FORCE ANALYSIS FOR DERRICK CRANE.

LOAD 10 TONS AT A JIB RADIUS OF 90 FT.



SPACE DIAGRAM. FORCE DIAGRAM.

Fig. 20

STATIC TEST.

DEAD LOAD STRESSES DUE TO:- A BENDING.
B DIRECT EFFECTS. C DERRICK ROPE EFFECTS.
Radius of jib 90 ft.
Distance of Test Section from jib bottom pin 61' - 4½"

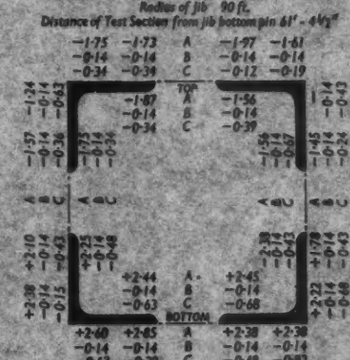


Fig. 21

Progress of the Metropolitan Water Board's New Works in 1953

THE Metropolitan Water Board's new works during 1953 retained much the same character as in the years immediately preceding, for continued restrictions on capital works prevented a start being made on any of the Board's proposed new reservoirs, or upon the stored water conduit from Staines to Ashford Common and Kempton Park. The Board has thus to rely on reducing the statutory flow over Teddington Weir during summer droughts, as the chairman noted at a recent meeting of the Board, during the course of a statement in which he professed some anxiety about the possibility of a shortage of water in the summer, as a result of the low winter rainfall experienced so far this winter.

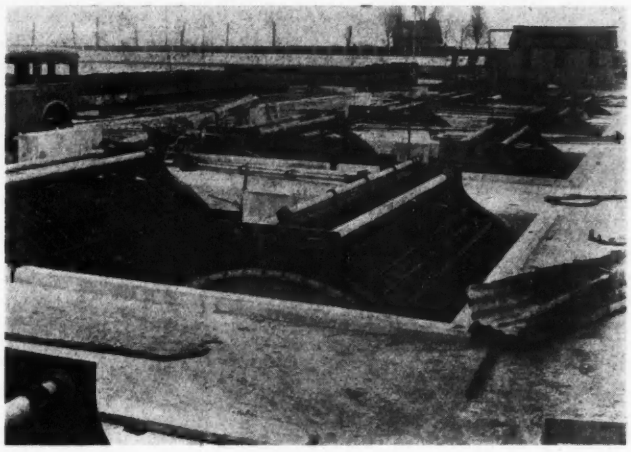
Nineteen fifty-three was the jubilee year of the Board, and in our issue of April 3rd last, the celebration of its fiftieth anniversary was recorded, with some information about its history. We also noted during the year (THE ENGINEER, July 10, 1953) the revised details of the scheme for laying a raw water main from the Thames to the Lee Valley (the conduit mentioned above). It is now planned to construct this main as a tunnel, concrete-lined with an internal diameter of 102in, constructed in the London clay at a depth sufficient to render unnecessary, except in some special places, the use of an inner lining of steel pipes. The concrete lining will consist of precast wedge-shaped segments, "Donsegs," as they are called, ten of which form a complete ring. During construction they are wedged in position by the hydraulic rams of the tunnel shield. This method of construction was devised to reduce the cost of the tunnel lining. It was originally intended to put a steel pipe inside the tunnel so formed, to carry the water, as was done with the first experimental length of tunnel constructed by this method at Stoke Newington. But a second "pilot" length was built at the Ashford Common filtration works comprising 630 yards of tunnel of 96in internal diameter, in which the "Donseg" lining was used without a steel liner. Elaborate measurements were made on this length, to ascertain how the lining and the surrounding clay behaved under hydrostatic pressure, and, the Board stated, the results justified the omission of the steel pipe. The new tunnel, therefore, will be built in the same manner, with considerable economy. The consulting engineers for the tunnel are Sir William Halcrow and Partners, and the cost of the tunnel will be about £5,000,000. A detailed description of the new method of lining with concrete segments was given in our issue of February 2, 1951, when the tunnel at Stoke Newington was under construction.

Ashford Common.—Further progress was made during the past year by the Board's contractors, John Mowlem and Co., Ltd., on the construction of the filtration works at Ashford Common, which was designed to provide a reliable supply of 90 m.g.d. of filtered water. The pilot tunnel referred to above was driven through the London clay at a depth of about 90ft below ground level and is now being used to convey stored water from the Queen Mary reservoir to the sixteen filters on the eastern side of the installation, the filtered water being delivered to Kempton Park by temporary pumping arrangements. The sixteen filters on the west side are being prepared for service.

Two aeration basins, each 90ft in diameter, were constructed and excavation work was in progress for the foundations of the centre block of the rotary strainer house. Twenty-four rotary straining units, each 10ft in diameter and 10ft effective length, are being manufactured by Glenfield and Kennedy, Ltd., and the first units will shortly be ready for delivery to the site. The two contact and balancing tanks, each of 5·8 m.g. capacity, were nearly finished at the end of the year and construction of the two low-lift pumphouses was well advanced. Exterior work to the main pumping station and the switchgear house was completed and the roof was being constructed on the transformer house. Work on the interior of the buildings continued and the erection of the machinery was proceeding. Site erection of a sand-handling bridge was nearing completion; this bridge spans the filter beds on the eastern half of the works and will operate in conjunction with a central sand-washing plant.

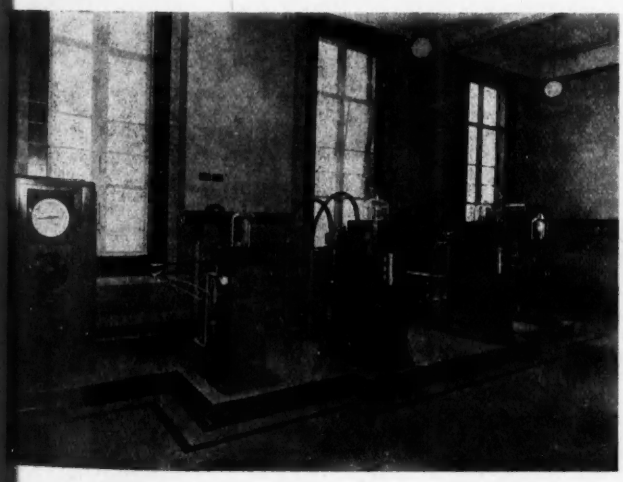
For the remaining half of the secondary filters, a sand-washing caisson, carried right across the filter bed on a steel bridge, will be lowered to isolate a section 1ft wide to a depth of 6in. for the full width of the bed. Pipes with lance heads will then be lowered inside the caisson to wash the strip of sand enclosed. Thus cleaning will be carried out *in-situ* while the filters are charged. A small prototype of this plant has been tried out by the Board, and a model of the proposed installation was displayed by the Board's chief engineer at the Institution of Civil Engineers' conversazione last summer. A full description of this novel design was given in the article "A Display of Engineering Models," in our issue of June 26th last.

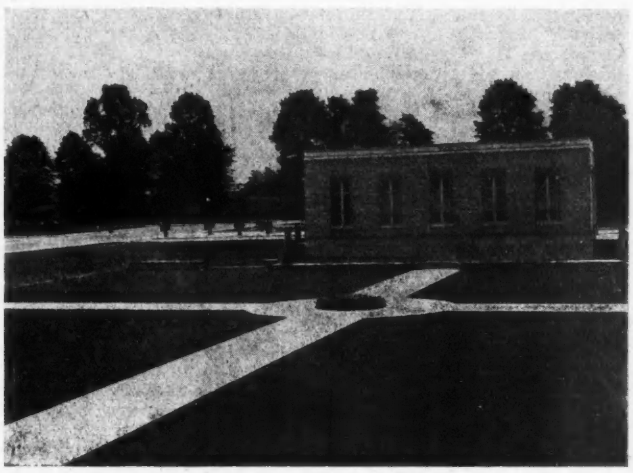
Finsbury Park.—As a result of an examination of the interior of the service reservoir at Finsbury Park in 1942 it was found that the brick arched roof was not water-tight and there was some percolation of ground water after heavy rain. An estimate of £40,000 was passed by the Board for its repair, which consisted of the removal of the earth covering, rendering the brickwork of the roof and waterproofing it with asphalt, replacing the earth and reinstating the surface. The work was carried out by Wallis and Stanley (Civil Engineers), Ltd., and the reservoir was put back into service in September.



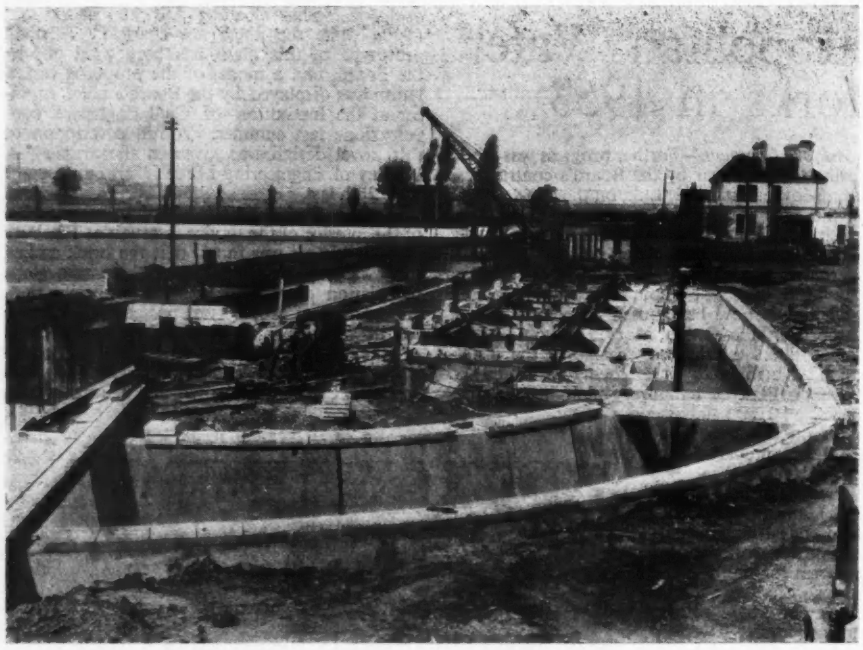
Rotary Screens in Partly Completed Screen House at Lee Bridge Works

Hampton.—Work continued during the year on the remodelling of these works, which is being done piecemeal, and will thus take many years to complete. The contract of F. R. Hipperson and Son, Ltd., for the construction of a new raw water pumping station at Sunnyside was completed in February, 1953, and all the pumping plant has been erected. The pumping connections were being laid by J. L. Eve Construction Company, Ltd., and should be completed by the early part of this summer. The clean sand store with a capacity of approxi-





Chlorination House at Hampton Works



Rotary Screen Installation with Screened Water Channel in Foreground at Lee Bridge Works

mately 18,000 cubic yards and access roads and ramps, together with the necessary sludge lagoon, was completed by direct administration and four sets of washing hoppers were installed. Roads and pavements were being constructed by direct administration in the portion of the works adjacent to the Stilgoe engine-house and the primary filters and soil and surface water drains in this area were laid by Wallis and Stanley, Ltd. Work was proceeding on the reconstruction of a filter bed. The accompanying illustrations show the interior and exterior of the new chlorination house.

Hornsey and Stoke Newington.—At Hornsey a contact tank was constructed and was under a test for water tightness at the end of the year, and a low-lift pump-house was substantially completed. Excavation for a contact tank at Stoke Newington was commenced at the beginning of the year, and the reinforced concrete east wall has now been constructed almost to its full height.

Knockholt Reservoir Zone.—In order to make full use of the output from the Sundridge and Brasted boreholes and to enable the Knockholt reservoir to take delivery from either or both of these sites, the Board approved a scheme for connecting the two sites with the reservoir and also for laying additional mains from the reservoir to the areas it serves where the demand for water has been considerably increased by post-war development. A contract was awarded to Whittaker Ellis, Ltd., for the laying of 3800 yards of 18in main from Knockholt to Berry's Green, and 2500 yards of 12in main from Berry's Green to Biggin Hill. Main-laying work commenced on November 30th and 350 yards of 18in main were laid by the end of the year.

Lee Bridge.—The installation of ten rotary strainers at Lee Bridge continued during 1953. Each strainer is 10ft in diameter and 10ft long, and they are arranged in five reinforced concrete chambers and housed in a building situated on the east bank of the Lee Bridge aqueduct. The rotary strainers are installed and work is now proceeding on the superstructure of the screening house. The accompanying illustrations show constructional work in progress with the rotary strainers installed.

Other Works.—Most of the 13¼ mile-length of the 60in trunk main from Kempton Park to Cricklewood was tested during the year. J. B. Edwards and Co. (Whyteleafe), Ltd., the contractor for the fourth section of the main, is now laying the connections in Cricklewood works and the whole of the work will be completed early this year.

During the year under review schemes for the installation of additional electrical pumping plant at Walton Works and the construction of new chlorinating houses and installation of chemical treatment plant at Hampton and Walton Works were also completed. Boiler shells were converted into high-pressure contact tanks at five of the Board's well stations.

Work continued on the remodelling schemes at Hadley Road, Hammersmith, Hoe Lane and Stoke Newington, and was commenced on remodelling schemes at Chingford Mill and Honor Oak. A 24in diameter borehole was sunk to a final depth of 204ft at Sundridge and at Bullfinch Lane, Riverhead, near Sevenoaks, boring for a 12in observation borehole reached a depth of 240ft.

Preparations were being made for the commencement of work in 1954 on a number of important schemes—Chingford South pumping station ; the raw water tunnel from the Thames to Lee Valley mentioned earlier ; laying 3350 yards of 24in main, Caversham Avenue, Southgate, to Great Cambridge Road, Edmonton ; and the first stage of the scheme for the improvement of supply to the Chigwell area.

Research and Development Work in the Gas Industry

An address on work in the gas industry was given by Colonel Sir Harold Smith to the Parliamentary and Scientific Committee in the House of Commons on December 1, 1953. Some abstracts from this address dealing particularly with the research and development work at present in progress are given below.

THE economy of the gas industry depends on the efficient use of coal. The industry is carbonising coal in quantities which steadily increase each year, and during the last financial year 27,590,000 tons of coal were carbonised. The gas industry is now in the position of not being able to obtain all the coal it requires of good coking and gas-making quality. There is not only a general shortage in coal supplies, but a particular shortage in the supplies of those qualities needed.

The most important research and development work in the industry at the present time is devoted to improvements in the technique of carbonising by orthodox methods, and the spreading of this improvement over wider areas ; research and development in connection with plants and processes designed to gasify more weakly caking coals which are in better supply ; investigations into the production and use of gas from sources other than coal, and a search for natural gas.

Increases in the production of therms per ton of coal carbonised as a result of improved efficiency have been from 71·62 in the year 1950–51 to 73·65 in the year 1952–53. The yield of coke and breeze per ton has been maintained. This improvement has not been due to any improvement in the quality of coal. The increase in thermal efficiency between the years 1950–51 and 1952–53 represents a reduction in terms of coal carbonised of 770,000 tons per annum. The increase in efficiency has been obtained by applying closer technical control to unit plants and also by putting into operation schemes of integration which have resulted in the closing down of some of the more inefficient plants.

Research into the possibility of widening the range of coals to be used in carbonisation has taken two main forms, both of which involve complete gasification processes, one being high pressure and the other low. The object of the research using high pressure is to develop a process or processes which will gasify at high efficiency any kind of coal, particularly low grade coal having a high ash content and being small in size. Original research is being conducted at the Gas Council's Birmingham research station, which has taken over work previously being carried out by the Gas Research Board, into a high-pressure complete gasification process involving the use of steam and oxygen, rather similar to the Lurgi process. The Lurgi high pressure process uses coal from 1in down to dust, it avoids oil for enrichment, but it does need to be installed in large units in order to justify the use of oxygen. The low-pressure process being investigated is the Gas Integrale process, which has been developed on the Continent. This process requires graded coal, the use of steam and needs oil for enrichment. It can be installed in small units if necessary. One of the area gas boards is already installing a plant of this kind, with the intention not only of using it as a gas-making plant, but also of ascertaining the different types of coal which the plant can handle. The Lurgi type of process appears to be more promising for ultimate development. It is more tolerant with regard to coal supplies, it offers greater possibilities for the gasification of dust, it is independent of oil and it will assist the present trend towards the production of gas in larger units by making gas available under pressure for transmission over long distances.

Investigations into the production and use of gas from sources other than coal are leading to research into the gasification of heavy oils. The opening of refineries in this country has resulted in the marketing of a considerable amount of heavy oil residues. This is of particular importance to the gas industry because of the increasing demand for the diesel oil fraction which, as gas oil, has been used for many years in the water gas process. Consideration is being given to two ways in which heavy oil may be used by the gas industry : it can be and is being used for water gas plants in a similar way to gas oil, and it can be used in separate oil gas plants especially designed for the purpose.

Liquefied petroleum gases in the form of butane or propane are now available from the new oil refineries in this country, and afford an alternative source of gas supply. Butane/air or propane/air mixtures can be supplied in place of normal town's gas. These processes are suitable for small communities which cannot be provided economically with a bulk supply from a larger works. A butane/air plant has been in operation at Whitland in Carmarthenshire for two years, and propane/air plants are likely to be operating shortly at Fishguard and Llanidloes. Butane/air plants are also at work at Bungay and Framlingham in the Eastern Counties.

Tail gases from oil refineries can be used by the gas industry, but on account of the uncertainty as to quality and quantity available no great progress has yet been made in their use. Methane is being drained from coal mines, and it is hoped will be available for distribution as town's gas. An experimental supply is being taken from the Haig Colliery at Whitehaven.

The latest line of inquiry which is being pursued by the gas industry is into the possibility of finding natural gas in Great Britain in quantities sufficient to be of commercial value After discussions between the Gas Council and

the Anglo-Iranian Oil Company, Ltd., it did appear worth while to make an exploration for natural gas. While only final boring can provide a satisfactory answer, the present information is sufficiently encouraging to justify the Gas Council in carrying out an extensive field investigation. Arrangements have been made in conjunction with the D'Arcy Exploration Company, Ltd. (a subsidiary of the Anglo-Iranian Oil Company), to carry out such an investigation over a period of five years at an estimated cost of £1,000,000.

Automatic Measurement and Control Instrument

PARTICULARS have been received from C. E. Johansson, Ltd., Southfields Road, Dunstable, Beds, of an instrument known as the "Deltameter," which can be used for accurate measuring or automatic control purposes. This instrument was invented and developed in Sweden by the Sandvikens Jernverks Aktiebolag for automatic measurement in that company's steel works. It was found that the instrument could operate continuously with heavy plant, in an atmosphere contaminated with oil fumes at varying temperatures, and in the vicinity of disturbing electric fields, without its accuracy or sensitivity being impaired. The system of measurement used had a wide field of application and in order to develop it for measuring, sorting, recording and regulating problems Aktiebolaget C. E. Johansson, Eskilstuna, Sweden, acquired the manufacturing and selling rights.

The instrument incorporates a pneumatically balanced measuring system and operates on normal compressed air supplies, pressure fluctuations in which do not affect its accuracy. Measurement is effected by the operation of a valve assembly in which there are two series of discs, one fixed, and the other on a central member actuated by the measuring point. The arrangement of the valve is shown diagrammatically in the drawing we reproduce. The measuring point is connected to the central member which is moved in accordance with changing dimensions or conditions.

The supply of air from a pressure regulator enters the valve through the hole *A* and is divided into two equal air streams, one directed upwards and the other downwards. Each air stream passes through two constricted passages formed by the narrow channels *B*, *C* and *D*, *E*. When the discs on the inner member are in a central position the two intermediate pressures are equal. One of the intermediate pressure chambers is connected to the measurement system through the orifice *F*, and the other through the orifice *G*.

If the movable inner member of the valve is raised the sizes of the constricting passages vary and there arises a difference between the intermediate pressures taken through the holes *F* and *G*. This pressure difference will be large as it is produced by the four co-operating constrictions. The intermediate pressures are transmitted to separate bellows in the measurement system. These bellows are arranged opposite to each other and their movable ends are connected with a yoke. It will be appreciated that as long as the pressures are equal the pull of the bellows on the yoke is equal in each direction and nothing happens. If, however, the pressures are unequal the whole system moves until the spring action of the bellows checks the movement. As the pressure difference may go up to more than 1·4 lb per square inch and the bellows area is about 1 square inch, the measuring forces exerted will be considerable. Consequently the measuring movement can be geared up and made to turn a large pointer at an effective speed.

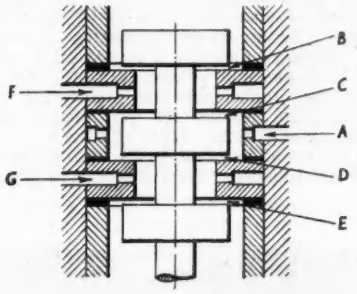
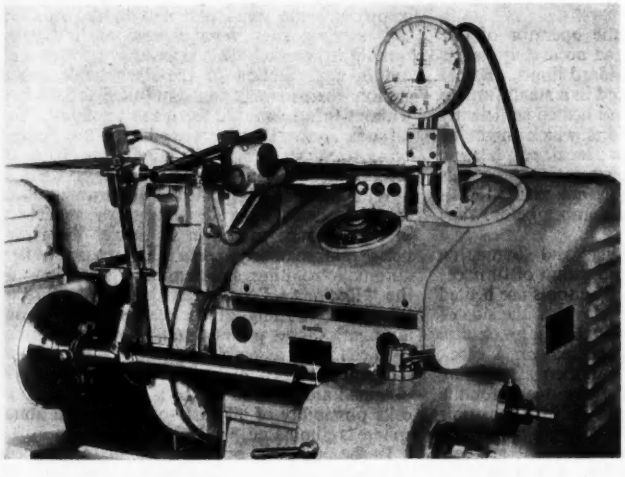


Diagram of the "Deltameter" Valve

The instrument is fitted with a screw adjustment which can be set to give the required amount of working air and a red float in a window is used to indicate if a sufficient supply of air is being maintained. The most suitable pressure at the connecting nipple of the instrument is 28–42 lb per square inch, and if the rate of supply is correctly adjusted the consumption of the instrument is stated to be about 10 cubic feet of air a minute.

In one form the "Deltameter" is used as a comparator and in it the valve is incorporated into the dial head alongside the bellows mechanism, the instrument having a relatively short shank inside which the measuring point spindle operates. When the instruments are used on grinding machines and rolling mills the valve is arranged as a separate unit in a small measuring head. A variety of these measuring heads are made for both internal and external measurements, and one fitted to a grinding machine is illustrated on this page. In this arrangement the head with its built-in valve is mounted on a frame through which it is connected by a spindle to the work measuring anvils. The head is connected to the size indicating dial by a flexible armoured hose having three separate air channels. Compressed air fed into the back of the dial unit passes along one channel to the valve head. From the valve the pressure difference to actuate the bellows in the dial head is transmitted by the air in the two other channels of the hose. Various adaptations can be made with the instrument to suit it for grinding cycle control, sizing, continuous measurement, &c.

The makers point out that this device can be adapted for sorting, separating components into groups, inspection, &c. In rolling mills it can be used for the continuous measurement and control of the thickness or width of strip, and through it, should certain limits be exceeded the plant can be either automatically adjusted or stopped.



Cylindrical Grinding Machine Equipped with Measuring Frame for Checking Diameters

British Non-Ferrous Metals Research Association

SINCE its early days the British Non-Ferrous Metals Research Association has assisted industry in the application of scientific knowledge to production processes. This work has not been confined to the exploitation of the association's own researches, although that, of course, has been one of the major objectives. The work is carried out by the Liaison and Technical Service Department and now accounts for over 20 per cent of the total expenditure of the association.

Under the Mutual Security Act, the Treasury is now making grants to finance projects intended to aid the economy of this country by promoting industrial productivity, and we are informed that the association has received an offer of up to £15,000 to be spent within the next three years on this work. It is proposed to spend a substantial part of this money in the provision of an advisory service to electro-platers and the rest will be devoted to the provision of certain new technical services for the lead pipe industry.

In consultation with members of the Metal Finishing Association and its own member companies having plating interests, the association is undertaking a scheme whereby a small team of investigators will visit plating shops by invitation to study methods of working, plant layout and other factors concerned principally with the technical aspects of plating practice. Observations made in a large number of plating shops of different types are being studied and the conclusions reached affecting matters of good practice in achieving high productivity will be made available in due course to firms with plating interests.

At the same time, the individual firms co-operating in the initial survey are advised where improvements could be effected practically and economically. If the initial survey indicates that it is likely to be useful, supplementary questionnaire surveys of somewhat wider scope will be undertaken.

In connection with this work, the association has set up a pilot scale plating line which operates on a continuous production basis. This plant embodies the best current plating practice and will serve to demonstrate methods of operation necessary for the consistent production of high quality plated coatings so increasing productivity by reducing waste.

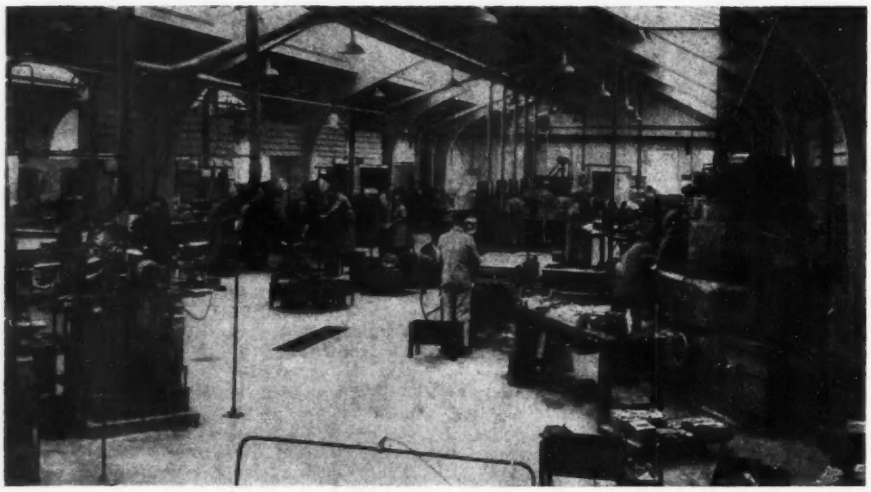
Very largely as a result of research sponsored by the Lead Sheet and Pipe Manufacturers' Federation and carried out by the British Non-Ferrous Metals Research Association over a number of years, knowledge has been accumulated of the mechanical properties of lead and the effect extrusion conditions have on it. This knowledge shows the way of improving efficiency in the use of lead in domestic water distribution pipes. The manufacture of pipes of improved quality for pressure services requires close control of the metallurgical condition of the lead and of the manufacturing process. With the requisite degree of control of these factors, the optimum mechanical properties of the material can be realised and a superior product possessing both technical and economic advantages obtained. In this connection the Association states that it is in a position to help the lead pipe industry with advice on methods of controlling the properties of its products to assist in increasing productivity.

DOCK IMPROVEMENTS IN EIRE.—Improvements at Dublin and Cork ports which will cost about £5,000,000 have been announced by the Department of Industry and Commerce. The Irish Government is providing over £2,000,000 of the outlay. The Dublin scheme, costing £3,500,000, will include a large new graving dock capable of taking ocean-going ships. The Cork scheme, which will cost over £1,500,000, involves reconstruction of quays, deepening of waterways for 10,000 tons ships and the provision of a turning basin.

Engineers' Tool Factory

IN order to make possible a reorganisation of plant layout the engineers' tool department of Edgar Allen and Co., Ltd., of Sheffield, has been transferred from the main works to a new factory in Shepcote Lane, near the firm's track manufacturing department. This transfer was recently completed and in the new factory there has now been concentrated all the plant for manufacturing on a progressive production basis the various types of tools for which the company is well-known. These tools include butt-welded cutting tools, precision ground form tools, tungsten carbide tools and tips, high-speed steel tool-holder bits, "Athyweld" deposit-welded high-speed steel tools, high-speed steel-faced woodworking knives, &c.

The new factory is a single-storey, four-bay, brick-filled, portal frame building 230ft long by 160ft wide, fronted by a two-storey office block. An impression of the interior of the



Grinding Bay of Tool Factory

building and the plant arrangement in one of the bays is given in the photograph we reproduce on this page. In these bays which have good natural and artificial lighting, ample room is left round the machines to give freedom of movement to the operators and easy access for transferring work between production stages. Space has been left for the introduction of new plant which can be readily connected to power lines laid in trenches along the gangways. The atmosphere is kept clear of dust and fumes by exhaust duct connections from each machine to overhead main trunks along each bay. Heating is by means of overhead radiant panels arranged along the length of the bays between the machine lines.

Raw materials in the form of bar and plate are either unloaded in a large stockyard adjoining one end of the main factory building, or delivered directly into a stores area in one corner of the building which is served by a 2-ton travelling crane. From the stores the bars are transferred to an adjoining group of saws, where the material is cut up and batched ready for the production lines. Steel plate used in the manufacture of certain of the large form tools is cut to shape on a profile flame cutter. A large majority of the standard tools made are of the firm's "Stag Major" "Superweld" design in which a tungsten cobalt high-speed steel cutting head is electrically fuse butt-welded to a medium carbon steel shank. It should be pointed out here that most of the large number of precision form tools made by the firm to special order are of similar construction.

The batched high-speed steel heads and mild steel shanks are first shot blasted to remove any scale and then transferred to the welding line where, on electric flash butt-welding machines of appropriate capacity for the size, the two parts of the tool are welded together. As each tool comes off the welding machine it is put straight into an adjoining furnace for normalising. This heat treatment is designed to relieve any internal stresses set up in the tool by the localised heat in welding.

From the welding section the tools pass to a group of pedestal grinders where the flash is removed to enable the joint to be thoroughly inspected before further processing is carried out. Standard tools are produced on a stock-flow basis and after welding are stored in stock blank bins. The tools are then taken on to groups of oscillating grinders for the initial forming of the cutting faces. These grinders are fitted with universal indexing heads into which the tools are clamped. With reference to graduations on the index heads the operator of one of these machines quickly and accurately grinds all the faces of a tool to standard limits. Before each tool is ground it is placed in a small furnace at the side of the machine and heated sufficiently to prevent any harmful effects which might be caused by "burning" or localised heating during the heavy grinding operation. At this stage of production the tools are marked with the maker's name and type number before they undergo heat treatment.

The subsequent hardening and tempering of the tools is carried out in a group of furnaces in one corner of the shop. The tools are heated in batches, air hardened on blasts at the side of furnaces and afterwards tempered in an electric furnace. Every tool is inspected on a crack detector after hardening, and then after being shot blasted is ground on the base ready for the subsequent finishing operations. The tools are finish ground on their cutting faces by skilled hand operators on pedestal grinders before they pass, via inspection, to the painting and packing section of the works.

The procedure in manufacturing special form tools follows that used in making the standard tools and the flash butt welding process is used to good effect where shanks of unusual shape are called for. Such shanks, instead of being formed by the somewhat lengthy and expensive forging process, are built up by welding together blocks of metal of appropriate shape. Then, after the high-speed steel blank has been attached, the assembly is annealed and machined to shape before heat treatment. After heat treatment, sand blasting and crack detecting, the special tools have their shanks ground and are sent on to a finish grinding section. In this section the tools with special profiles are finished on precision tool and cutter grinders using diamond-formed wheels. The finish grinding section has an adjoining projection room equipped with three projectors of five, ten and twenty times magnification, respectively; if necessary higher magnifications can be achieved.

In addition to being responsible for inter-operational checking a central inspection department has to approve all tools before they leave the manufacturing departments for painting, packing and despatch.

A few years ago this firm introduced its "Athyweld" process which has been widely adopted for the manufacture of tools that are slender or fragile and likely to fracture in service if their blades were made of solid high-speed steel. The process also permits economy in the manufacture of certain types of form tools and machine knives where only a small cutting edge is required on a large profile or heavy shank. The process is one of atomic hydrogen welding with close carbon control, and by it a wide variety of high-speed or tool steels can be deposited without reduction of the carbon content. Tools built up by this form of deposit welding can be annealed, hardened, ground, &c., in exactly the same way as normal high-speed steel tools. A section of the new works engaged in making tools by this process consists of a group of welding cubicles to which the ready-formed or recessed shanks are sent from the machine lines. If subsequent machining operations are required on the tools they are annealed in a special furnace immediately after welding, otherwise they go straight to the heat treatment and grinding lines. This deposit process, in addition to being used in the manufacture of engineers' and woodworking tools, is also used for hard facing purposes, rebuilding worn tools and parts, &c.

Each class of tool made by the firm is painted a distinctive colour and the head protected by a plastic coating in a finishing section before it is delivered to an adjoining stock and packing department.

Rotating Self-Cleaning Air Filter

AN improved design of rotating, self-cleaning, oil-wetted air filter for handling large volumes of heavily dust-laden air over long periods is now being made by the Visco Engineering Company, Ltd., Stafford Road, Croydon, Surrey. This design of filter was first introduced by the company some years ago and in it successive cell filtering units were cleaned each day by turning a handle. This operation brought one cell in each section of the filter bank into a station where it was cleaned, re-oiled and drained without being removed from the assembly. The oil was sprayed under pressure on to the cell being cleaned, dirty oil gravitating back to settling tanks through troughs.

With these hand-operated, self-cleaning filters trouble was experienced owing to the reluctance of maintenance personnel to service them properly and regularly. For this reason a new automatic rotating, self-cleaning filter, known as the "Reciprojet," has been developed. In this filter, the cleaning of the cells is carried out automatically at preset times. By ensuring that each cell in an assembly is thoroughly cleaned at frequent intervals higher filtration efficiency is obtained and by the use of a double column of cells possibility of oil carry-over into the atmosphere is eliminated.

In the new filter one or more sections of cells of heights to suit the required capacity are used. Each section comprises a mild steel frame having two columns of filter cells supported in carrier plates attached to two endless chains, and at the base of each section is a large oil tank. With the automatic control system fitted to the filter an electrically operated time switch, at predetermined times, starts up a fractional horsepower motor, which drives the filter column chains and an oil pump motor. This drive brings the dirtiest cell in each section into the cleaning position, where it is subjected to the scouring action of a number of oil jets which move backwards and forwards across the width of the cell. The dirty cell is initially tilted to allow the oil jets to wash the dirt forward and downwards through the

cell plates and as the cell continues to move, the oil jets effectively scour the front or dirty face.

When the filter columns have been moved a distance equivalent to one cell, a limit switch cuts out the filter and oil pump motors, the time switch then again taking control. Whilst the filter is in operation the oil in the system is cleaned by an oil strainer unit of sufficient capacity to clean all the oil at least once between each spraying operation. The dirty oil remains in the filter tanks in which sludge settles out for eventual removal, or, if preferred, it can be drained away to a central settling tank.

In addition to the improved cleaning effect and the automatic operation of the "Reciprojet," the filtration efficiency is stated also to be considerably increased by the double column of cells through which the dust-laden air has to pass. As the cells in the column on the cleaned air face of a filter assembly have been previously in use on the upstream side of the filter, the oil coating on the cell plates will have dried to some extent and these cells act as a trap for any oil carried over from the front cells. Oil eliminator plates are fitted as an additional safeguard against oil carry over.

Mechanised Materials Handling Plant for a Foundry

UNDER a modernisation scheme carried out during recent years at the works of Leyland Motors, Ltd., Leyland, Lancs, various sections of the foundry have been mechanised to meet the increasing demands for iron castings. A further step in the plan to increase productivity has been made by the introduction of a mechanical handling plant in the pig iron stockyard which serves the foundry cupolas. We are informed that preliminary trials with this installation have not only shown there is a considerable saving in man-hours, but that it also provides a closer quality control; a means of consistent and continuous furnace charging; and a higher degree of safety for the men employed in the stockyard.

With the new layout bulk stores of pig iron and other ingredients for the castings are stored in separate piles in the stockyard, each pile having a different metallurgical content. From these piles the materials are transferred by a 5-ton gantry crane to walled-off containers or bins which flank both sides of a miniature railway line, and coke is dumped into an overhead hopper. The crane runway is 200ft long, 35ft high and it has a span of 35ft 6in. The crane is fitted with a 1-ton grab when used for transferring coke from the stockpile to the hopper, and a 10 cwt magnet for handling iron.

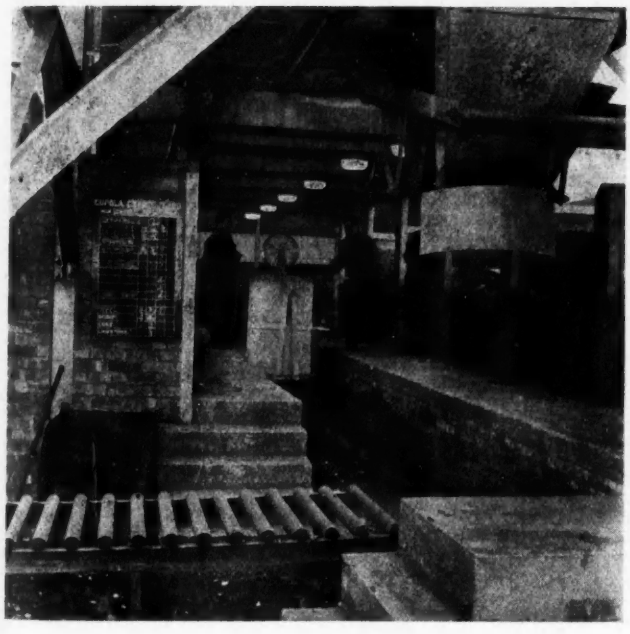
An impression of the raw materials containers and the railway line is given in a photograph we reproduce on this page. A mobile weighing machine which runs along the track carries drop-bottom skips. As this weighing machine is moved along its rail track its skip is loaded by hand with the correct weight of various grades of pig iron, and limestone, from the working quantities stored alongside in the bins. At the end of the track the predetermined quantity of coke is weighed into the skip from the overhead hopper. This hopper, which has a capacity of 12 tons, can be seen in the second illustration.

All skip loading is carried out under cover and each ingredient for making an iron casting is proportioned speedily and accurately. The plant is so arranged that the height of the top of the skip on the weighing carriage is level with the loading platforms, so that loading can be effected without unnecessary lifting or undue manual effort on the part of the operators.

After each skip has been loaded it is propelled along a roller conveyor to a station below a 34ft high hoist or telpher. This telpher raises each skip in turn and carries it along a mono-rail and branch rails leading to four furnaces into which the skips are quickly discharged. Empty skips are returned by the hoist to a second roller conveyor along which they are propelled to the head of the loading line ready for placing on the mobile weighing machine for recharging. The full skip conveyor can be seen on the right in the second illustration, where an empty skip is being dropped by the hoist onto the adjacent return conveyor on the left. A number of skips are kept in circulation in the plant and one with a full charge leaves the loading bay every six minutes.

A new plant has also been laid down for manufacturing cast iron briquettes from turnings and borings from the machine shops. This plant forms 2¼ lb briquettes at a rate of 540 per hour in a toggle press, and it is dealing with some 20 tons of material a week.

We are informed that the layout and equipment for the mechanised weighing plant was planned by Leyland Motors, Ltd., and built and installed by the Paterson Hughes Engineering Company, Ltd. The briquetting plant was supplied by William Johnson and Sons, Ltd.



Skip on Mobile Weighing Machine Moving on Rails Between Materials Bins

Overhead Coke Hopper at End of Loading Line and Full and Empty Skip Roller Conveyors

Guided Missile Control

ALTHOUGH no detailed information is available on the control mechanisms of guided missiles, sufficient has been released to indicate the general principles which are common to the guidance systems of them all. A missile can be homed on to its target either by what is called "passive" homing, where the missile homes on to a source of energy radiated by the target, or by "active" homing, where the missile itself transmits energy which is reflected back from the target, thus locating its position in space. This source of energy radiated or reflected by the target can be any of the various forms of energy produced by an aeroplane in flight—heat, noise, wake, infra-red radiation, static electricity, &c. Some of these can be detected many miles away, others at only quite short range.

By fitting the missile with a detector or receiver which will pick up responses from the target, amplify them, and pass the information as to their direction and strength to the controls of the missile, the missile will then be automatically guided to the source of energy, and it will ultimately hit the target. This, in the simplest terms, is "passive" homing, and it is usually a relatively short-range technique.

Targets at Longer Ranges.—To pick up targets at longer range, "active" homing is used where the missile itself transmits energy and picks up the reflection from the target which is, in turn, used to steer the missile on to it. The missile has therefore to carry a transmitter as well as a receiver, a radar set being an obvious method of using the technique. The drawback is the weight of equipment necessary and the size the missile must be if an aerial and a heavy power supply have to be carried. Consequently, though the system can be a long-range one, in practice its bulk keeps down the distance over which it can be used. These limits on the size of the transmitter can be overcome if, instead of carrying it in the missile itself, the transmitter is placed somewhere else—for instance, in a larger aircraft, or on a ship or on land. In this way the complete guidance system is a remote high-power transmitter, with a smaller receiver in the aircraft capable of directing a missile to the source of reflected energy. This is known as the "semi-active" homing system, and it is at present accurate over ranges of the order of 17 miles.

Another system of guidance which gives about the same results as "semi-active" homing is "beam riding." A radar beaming device in

another aircraft or on a ship or the ground locates the target and locks on to it. The missile is fitted with a rearward-looking receiver which, together with the control system, ensures that the missile flies dead along the centre of the beam. As the beam is locked on to the target, the missile will ultimately hit it.

The disadvantage of these two long-range systems—the semi-active homing and beam riding—is that because the transmitting source of energy is based away from the missile, the further the missile flies from the transmitter, the less accurate is the information which it receives to guide it. But as the distance from the target closes the more accurately must the missile be navigated.

This handicap is overcome by carrying yet another transmitter in the missile itself. This is not switched on until the closing phase of the interception, because for the greater part of its journey the missile's course is controlled by the information picked up by its receiver from the surface control. The receiver in the missile is common to both the ground and airborne transmitter.

If a number of missiles are being launched from widely separated points, they must all be headed in the approximate direction of the target. For this reason it is necessary to have a "gathering" phase before the active homing begins.

A long-range interception by guided missiles would, therefore, consist of a "gathering" phase when the weapons are headed in the correct direction, followed by mid-course navigation, and, last, a "final terminal or homing" phase.

Control Systems

The controls of these missiles are rather different from those at present fitted to most piloted aircraft, largely because the missile attains supersonic speed within one or two seconds of the time it is launched, and stays supersonic throughout its life in the air. The control and lifting surfaces are usually sharp edged and razor thin, and quite small surfaces can produce large forces which enable the weapons to manœuvre at seven to twenty "g," a range well beyond the capabilities of piloted aircraft.

There are two main methods of control. One is called the Cartesian method, the other the polar control system. Missiles guided by the Cartesian method have two sets of "wings" fitted at right angles to each other—that is, four wings forming a cross round the fuselage. Movable control surfaces are fitted to the wings and the missile is gyroscopically stabilised.

If the guidance system requires the missile to turn to the left or the right, the vertical control surfaces are operated, and if the missile is required to go up or down, the horizontal surfaces are moved. For a climbing or diving turn to reach the target, the combined use of all four controls wrench the missile round in a skidding turn in the direction of its objective—quite unlike the operation of a piloted aircraft, which, when turning, must first be rolled in the direction of the turn.

Polar Control.—Missiles using the second method of control, the so-called polar system, have a configuration more like that of a conventional aircraft. They have only two wings, with one pair of controls arranged to work in opposite directions like ailerons, and another set working together like elevators in the conventional aircraft.

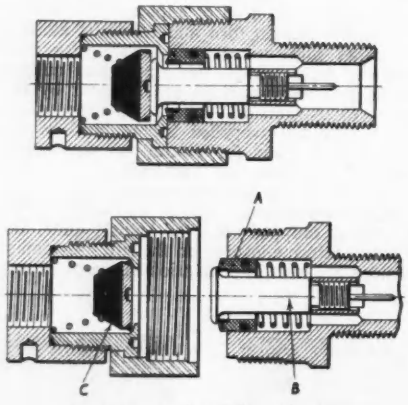
Flight is again stabilised by gyros. The receiver in the missile controls its movement by measuring the angle between the target response and the line of flight of the missile, and the range of the target. The missile is then rolled until its wings are at right angles to the line between the missile and the target. The elevators then pull the nose up or down until it is pointing directly at its objective. In other words, the weapon is first rolled or twisted into an appropriate position and then steered to its target (it is sometimes called "twist and steer" control), a rapid and accurate method similar to that used by a pilot in any conventional aeroplane. Missiles using the polar method of control sometimes spiral as they get close to their target. In the simplest missiles, the wings are "all moving," so that they combine the functions of the lift-producing surfaces with the controls.

The mechanism which connects the "brain" of the missile to the control system is similar to that used in aircraft auto-pilots, but very much more compact and capable of standing much higher "g" forces.

Self-Sealing Pipe Coupling

Some particulars have been received from Dowty Auto Units, Ltd., Ashchurch, near Tewkesbury, of a self-sealing coupling for pipes carrying fluids at working pressures up to 3000 lb per square inch. The couplings are stated to be leak-proof and pipes fitted with them can be coupled and uncoupled under working pressure without the loss of fluid and by hand without the use of special tools.

The construction and method of operation of the coupling can be seen in the drawing we reproduce herewith. The body of the male member is bored out to accommodate a spring-loaded sliding piston *A* which has two annular rubber sealing rings bonded in its head. When the coupling is unscrewed the piston is urged



Arrangement of Coupling Members

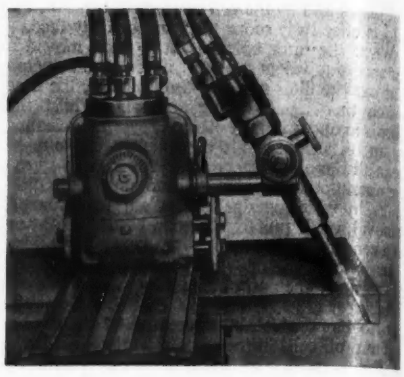
forward by the spring into contact with a mush-room-headed valve *B* screwed in a bore at the rear of the body. In this position the head of the piston projects in front of the body and the inner sealing ring registers on the mushroom valve to prevent any of the fluid in the pipeline escaping.

A conical valve *C* in the female member of the coupling is held in pressure tight contact with its seating by a spring whilst the unit is uncoupled. When coupling a pipeline as the two members are screwed together, the head of the piston first contacts the opposite side of the seating of the valve *C* and its outer sealing ring forms a pressure tight joint. Further tightening of the coupling presses the piston rearwards whilst at the same time the head of the valve *B* pushes the valve *C* off its seating to open a passage for the pressure fluid to pass through the coupling. The outside of the female member is formed with projections to give an adequate grip for the hands when tightening to ensure a leak proof joint.

Oxygen Cutting Machine

A new oxygen cutting machine made by the British Oxygen Company, Ltd., Bridgewater House, Cleveland Row, London, S.W.1, weighs just under 23 lb and is adaptable for straight line, circle or profile cutting of plate. It can cut mild steel plate up to 2in thick, and when fitted with a radius bar cuts circles of between 3in and 45in diameter. In one of the photographs we reproduce herewith the machine can be seen operating on a guide track and cutting a bevel along a plate; and in the other being guided by hand along a line marked on the surface of a plate.

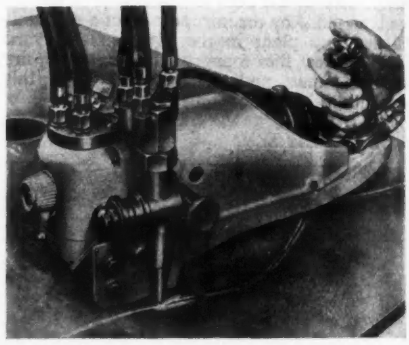
The machine is mounted on wheels and is driven by a small reversible electric motor, the speed of travel being variable from 30ft to 130ft per hour, through a rheostat control at the back of the motor. The carrying handle



Oxygen Cutting Machine Running on Track

fitted at the trailing end immediately above the gas inlets can be used to steer the machine when following curves. When the machine is arranged to run on a track for straight line cutting a castor trailing wheel is locked in line, and this wheel is disengaged to swing freely when circular or hand guided cutting is in progress. The straight track is supplied in 3ft lengths and sections are designed for quick coupling into long runs if required.

Oxygen and acetylene gas valves for controlling the preheat flame are mounted on the body of the machine away from heat rising



Oxygen Cutting Machine Being Guided by Hand Over Plate to Cut a Contour

from the cutter. All the other controls are grouped adjacent to the handle to enable the driving motor and the cutting oxygen supply to be switched on together.

The "Cutogen" one-piece nozzle used on the machine is mounted in a head on a bracket at the end of an arm projecting from the side of the body. Rack adjustment is provided for horizontal and vertical setting of the cutter head. A vertical adjustment of 2¼in and a horizontal adjustment of up to 4in can be made to the head, which can also be inclined on the arm up to 45 deg. for bevel cutting. The makers state that in straight line cutting a ½in plate can be cut at a speed of 130ft per hour with a ⅛in nozzle, or a 2in plate at 40ft per hour with a ¼in nozzle.

Nickel Alloy Spring Materials.—In addition to the usual requirements of adequate mechanical strength, springs must often be used in conditions which add further problems in specifying the material which will give the required properties. Such requirements may include resistance to corrosion to minimise failure due to corrosion-fatigue, or resistance to high-temperature conditions. Sometimes a special characteristic is required such as a-magnetism at temperatures in the sub-zero range, or low or high electrical or thermal conductivities; sometimes a combination of characteristics is required, as, for instance, in springs for accurate instruments, where low thermal expansion and zero thermo-elastic coefficients are desirable. Such properties and characteristics are available in the wide range of high-nickel alloys and a recent publication, *Nickel Alloy Spring Materials*, issued by Henry Wiggin and Co., Ltd., presents in convenient form data to assist the designer to make the correct selection of materials. First published two years ago, this revised edition of the book now contains data on Nimonic 90, an alloy stated to be particularly suitable for springs operating at high temperatures.

Industrial and Labour Notes

Railway Wages

The railway unions have accepted the offer of a 6 per cent increase in wages and salaries which was made a fortnight ago by the British Transport Commission. The 6 per cent, which includes the 4s. a week increase awarded at the beginning of December on the recommendation of the Railway Staff National Tribunal, dates from January 24th.

The National Union of Railwaymen, however, has expressed its disappointment about the Transport Commission's latest offer. It has stated that its acceptance has been given on the understanding that the offer is in the nature of an "interim settlement" whilst the Transport Commission and the unions proceed with an examination of the whole wages structure and an investigation of the standard rates of pay. The cost of the increases to those directly concerned has been estimated at about £12,500,000 a year, and the Transport Commission has already intimated that the 10 per cent increase in freight charges, for which it has applied, does not provide for any additions to wages beyond the 4s. a week already in operation.

Freight Charges

The Association of British Chambers of Commerce has sent a memorandum to the Minister of Transport urging him to exercise his powers under the Transport Act, 1947, to prevent a further substantial increase in railway freight charges. The memorandum expresses the Association's conviction that further advances in the wages of railway staff should be related to increased efficiency and the transfer of redundant railway personnel to other branches of industry and commerce.

The main point in the Association's opposition to a further increase of 10 per cent in freight charges is that it would do no more than continue the spiral of operating costs chasing charges and would not, therefore, solve the railways' economic problem. The memorandum says that "whether the Commission is the cause or the victim the fact remains that there exists an inflationary spiral, in which rises in the prices of coal, iron and steel invariably follow advances in freight charges."

The memorandum calls upon the Government to set up a working party representative of the Government, the Transport Commission, trade unions and transport users to investigate the urgent economic problems of British Railways "in a modern setting" and to reach agreed solutions. Some salient factors which should predominate in such an inquiry, the memorandum says, are the possible under-utilisation of rail carrying capacity and the existence of a surplus which can only be justified on national strategic or social, rather than economic, grounds; the achievement of economies in operation through the modernisation, reorganisation and streamlining of the railway system, and the whole question of the capitalisation of British Railways.

Changes in Wage Rates

The changes in wage rates which were reported to the Ministry of Labour as becoming effective in December last in the United Kingdom resulted in an aggregate increase of about £152,000 in the weekly full-time wages of 736,000 workpeople, and in a decrease aggregating about £120 for 2500 people. The decreases occurred under sliding scale arrangements based on the index of retail prices.

The Ministry of Labour says that over the whole of last year there was an increase in the average level of weekly wage rates of about 3 per cent, compared with about 6 per cent in the preceding year and 11 per cent in 1951. The index of weekly wage rates (June, 1947=100) stood at 138 for all workers at the end of last December, compared with 134 a year earlier. It has also been calculated that during last year about 9,000,000 workpeople received increases in wages aggregating nearly £2,500,000 a week, and it must be remembered that as the year ended there were a number of wage claims still outstanding.

Surveying the principal changes in wage rates last year, the Ministry shows that in the group of industries classified generally as "engineering, shipbuilding, electrical goods, and vehicles" about 149,000 workers received weekly wage increases aggregating £41,900, against £1,168,900 received by 2,975,500 workers in the same industries during the preceding year. In coal mining, the increase of 6s. in the national weekly minimum wage and other consequential increases, which were made last February, meant that 462,000 workers received additions to their weekly wages aggregating £129,700. In transport and communication, 898,000 workers last year received increases amounting to £226,500 a week. This, of course, included the 4s. a week increase in December to adult male workers employed by British Railways and proportional increases made to adult female and juvenile employees.

Industrial Production

The Central Statistical Office of the Treasury has estimated the index number of industrial production (1948=100) at 132 for all industries in November last, compared with 129 in October. The numbers for the corresponding months of 1952 were 123 in November and 119 in October. Taking the manufacturing industries alone, the index number for last November has been estimated at 134, compared with 124 in November, 1952, whilst in mining and quarrying the estimate for November last is 120, against 117 a year earlier. The Treasury says that information so far received indicates that the index for all industries in December may be 120 or 121, compared with 112 in December, 1952. It also says that the estimate for the whole of 1953 is 120, compared with 114 for 1952 and 117 for 1951.

Management and Unions

On Thursday of last week, Mr. Graham Hutton spoke at a meeting in Manchester which was organised by the British Productivity Council. In the course of his address he claimed that any recipe for raising productivity must start with management, and went on to say that whilst the best British management would equal the best anywhere, the average level seemed to be lower than the average in countries which had outstripped Britain. British management, Mr. Hutton asserted, needed to become more of a professional skill studied and learned in the firm and outside it. He thought that management should be more "on its toes" in the sense of being more enterprising, venturesome and pioneering in the application of new methods.

In the trade union world, as in management, Mr. Hutton continued, the chief problem was to raise the average level of understanding of modern economic problems, whether the workplace was privately or publicly owned, and then to approach those problems with fresh minds. The unions to-day, Mr. Hutton observed, did not stand to gain half as much from the old-fashioned ways of negotiating and bargaining as they could now gain from the far better armoury of detailed argument on accountancy figures, work study calculations, work-load figures and other "experts' weapons."

Production and Distribution Censuses

Last week, the President of the Board of Trade, Mr. Peter Thorneycroft, was questioned in Parliament as to the cost and value of the censuses of production and distribution. In a written reply, the President stated that the present cost of the annual census of production, as required by the Statistics of Trade Act, 1947, was about £175,000. The total cost of work on the first census of distribution, which began in 1949 and, apart from collation and publication, was completed by the end of 1951, would be about £710,000. It was essential, Mr. Thorneycroft added, that the cost of any such work should be justified by the benefit that it brought to industry and the community. He had therefore appointed a committee, which included representatives of industry and commerce, to advise him on future policy about the taking of censuses of production and distribution. Among other matters, that committee would examine the uses to which the censuses were put.

Trade Disputes

The Ministry of Labour's statistics about stoppages of work through industrial disputes in December last show the effect of the "token stoppage" on December 2nd of workers in the engineering and shipbuilding industries. Altogether, in December, 140 stoppages of work occurred, involving 1,080,500 workpeople and causing an aggregate loss of 1,115,000 working days. According to the Ministry's figures, 1,050,000 engineering and shipbuilding workers participated in the stoppage in December.

The total number of stoppages of work through industrial disputes in the United Kingdom, which were reported to have begun in 1953, was 1746. In them, 1,352,700 workers were involved with the result that approximately 2,169,000 working days were lost, compared with 1,792,000 in 1952. In surveying last year's stoppages of work through disputes, the Ministry of Labour has said that the biggest of them was the one-day token stoppage in the engineering and shipbuilding industries. It accounted for about one-half of the total number of working days lost in the year. The largest number of stoppages again occurred in the coal mining industry. They accounted for nearly one-fifth of the aggregate loss of time in 1953 and for about one-twelfth of the total number of workers involved in all stoppages in the year. The Ministry of Labour says, however, that most of these stoppages were of short duration.

Representations on the Budget

Following its customary practice, the National Union of Manufacturers has submitted to the Chancellor of the Exchequer a memorandum setting out certain matters which it hopes will be kept in mind in the framing of the 1954 Budget. While the National Union gladly acknowledges that the last Budget provided an "incentive motive" for the first time for many years, it feels that the present excessive level of taxation does not provide a sufficient margin of reward for industrial effort or for risk successfully undertaken. It is submitted also that current taxation is eating away the capital resources of industry.

Among the specific suggestions made in the memorandum there is again included the abolition of the purchase tax, which, it is urged, "creates difficulties throughout the merchanting and manufacturing world." The National Union of Manufacturers also suggests that a reduction in the standard rate of income tax would enable industry to retain and make use of a larger proportion of its profit and would also increase the volume of private savings available for industrial investment. The memorandum then recommends that the profits tax on undistributed profits should be abolished, commenting that whatever justification there may be for taxing distributed profits, there can be none for taxing profits which are ploughed back into the business. Another comment made in the memorandum is that the existing wear and tear allowance for income tax purposes on plant, machinery and buildings bears no relation to the present costs of replacement. These allowances, it is considered, should be increased accordingly in order to provide for replacement by up-to-date plant. The memorandum also suggests that, in order to encourage fuel economy, expenditure on approved fuel saving plant and equipment should be allowed as a trading expense for income tax and profits tax purposes in the year in which it is incurred.

another aircraft or on a ship or the ground locates the target and locks on to it. The missile is fitted with a rearward-looking receiver which, together with the control system, ensures that the missile flies dead along the centre of the beam. As the beam is locked on to the target, the missile will ultimately hit it.

The disadvantage of these two long-range systems—the semi-active homing and beam riding—is that because the transmitting source of energy is based away from the missile, the further the missile flies from the transmitter, the less accurate is the information which it receives to guide it. But as the distance from the target closes the more accurately must the missile be navigated.

This handicap is overcome by carrying yet another transmitter in the missile itself. This is not switched on until the closing phase of the interception, because for the greater part of its journey the missile's course is controlled by the information picked up by its receiver from the surface control. The receiver in the missile is common to both the ground and airborne transmitter.

If a number of missiles are being launched from widely separated points, they must all be headed in the approximate direction of the target. For this reason it is necessary to have a "gathering" phase before the active homing begins.

A long-range interception by guided missiles would, therefore, consist of a "gathering" phase when the weapons are headed in the correct direction, followed by mid-course navigation, and, last, a "final terminal or homing" phase.

Control Systems

The controls of these missiles are rather different from those at present fitted to most piloted aircraft, largely because the missile attains supersonic speed within one or two seconds of the time it is launched, and stays supersonic throughout its life in the air. The control and lifting surfaces are usually sharp edged and razor thin, and quite small surfaces can produce large forces which enable the weapons to manœuvre at seven to twenty "g," a range well beyond the capabilities of piloted aircraft.

There are two main methods of control. One is called the Cartesian method, the other the polar control system. Missiles guided by the Cartesian method have two sets of "wings" fitted at right angles to each other—that is, four wings forming a cross round the fuselage. Movable control surfaces are fitted to the wings and the missile is gyroscopically stabilised.

If the guidance system requires the missile to turn to the left or the right, the vertical control surfaces are operated, and if the missile is required to go up or down, the horizontal surfaces are moved. For a climbing or diving turn to reach the target, the combined use of all four controls wrench the missile round in a skidding turn in the direction of its objective—quite unlike the operation of a piloted aircraft, which, when turning, must first be rolled in the direction of the turn.

Polar Control.—Missiles using the second method of control, the so-called polar system, have a configuration more like that of a conventional aircraft. They have only two wings, with one pair of controls arranged to work in opposite directions like ailerons, and another set working together like elevators in the conventional aircraft.

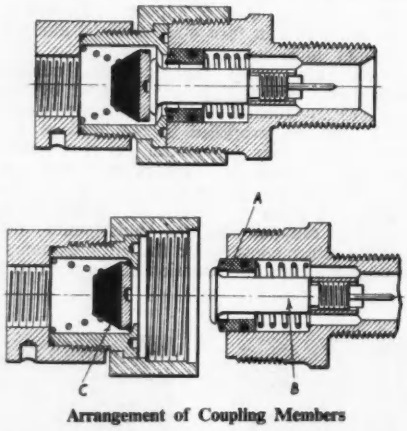
Flight is again stabilised by gyros. The receiver in the missile controls its movement by measuring the angle between the target response and the line of flight of the missile, and the range of the target. The missile is then rolled until its wings are at right angles to the line between the missile and the target. The elevators then pull the nose up or down until it is pointing directly at its objective. In other words, the weapon is first rolled or twisted into an appropriate position and then steered to its target (it is sometimes called "twist and steer" control), a rapid and accurate method similar to that used by a pilot in any conventional aeroplane. Missiles using the polar method of control sometimes spiral as they get close to their target. In the simplest missiles, the wings are "all moving," so that they combine the functions of the lift-producing surfaces with the controls.

The mechanism which connects the "brain" of the missile to the control system is similar to that used in aircraft auto-pilots, but very much more compact and capable of standing much higher "g" forces.

Self-Sealing Pipe Coupling

Some particulars have been received from Dowty Auto Units, Ltd., Ashchurch, near Tewkesbury, of a self-sealing coupling for pipes carrying fluids at working pressures up to 3000 lb per square inch. The couplings are stated to be leak-proof and pipes fitted with them can be coupled and uncoupled under working pressure without the loss of fluid and by hand without the use of special tools.

The construction and method of operation of the coupling can be seen in the drawing we reproduce herewith. The body of the male member is bored out to accommodate a spring-loaded sliding piston *A* which has two annular rubber sealing rings bonded in its head. When the coupling is unscrewed the piston is urged



Arrangement of Coupling Members

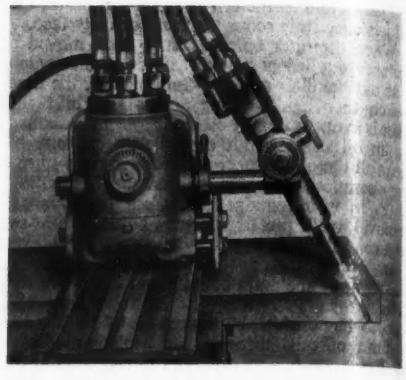
forward by the spring into contact with a mushroom-headed valve *B* screwed in a bore at the rear of the body. In this position the head of the piston projects in front of the body and the inner sealing ring registers on the mushroom valve to prevent any of the fluid in the pipeline escaping.

A conical valve *C* in the female member of the coupling is held in pressure tight contact with its seating by a spring whilst the unit is uncoupled. When coupling a pipeline as the two members are screwed together, the head of the piston first contacts the opposite side of the seating of the valve *C* and its outer sealing ring forms a pressure tight joint. Further tightening of the coupling presses the piston rearwards whilst at the same time the head of the valve *B* pushes the valve *C* off its seating to open a passage for the pressure fluid to pass through the coupling. The outside of the female member is formed with projections to give an adequate grip for the hands when tightening to ensure a leak proof joint.

Oxygen Cutting Machine

A new oxygen cutting machine made by the British Oxygen Company, Ltd., Bridgewater House, Cleveland Row, London, S.W.1, weighs just under 23 lb and is adaptable for straight line, circle or profile cutting of plate. It can cut mild steel plate up to 2in thick, and when fitted with a radius bar cuts circles of between 3in and 45in diameter. In one of the photographs we reproduce herewith the machine can be seen operating on a guide track and cutting a bevel along a plate; and in the other being guided by hand along a line marked on the surface of a plate.

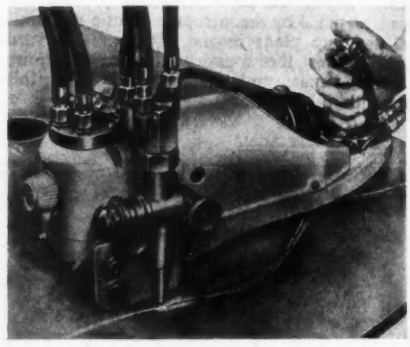
The machine is mounted on wheels and is driven by a small reversible electric motor, the speed of travel being variable from 30ft to 130ft per hour, through a rheostat control at the back of the motor. The carrying handle



Oxygen Cutting Machine Running on Track

fitted at the trailing end immediately above the gas inlets can be used to steer the machine when following curves. When the machine is arranged to run on a track for straight line cutting a castor trailing wheel is locked in line, and this wheel is disengaged to swing freely when circular or hand guided cutting is in progress. The straight track is supplied in 3ft lengths and sections are designed for quick coupling into long runs if required.

Oxygen and acetylene gas valves for controlling the preheat flame are mounted on the body of the machine away from heat rising



Oxygen Cutting Machine Being Guided by Hand Over Plate to Cut a Contour

from the cutter. All the other controls are grouped adjacent to the handle to enable the driving motor and the cutting oxygen supply to be switched on together.

The "Cutogen" one-piece nozzle used on the machine is mounted in a head on a bracket at the end of an arm projecting from the side of the body. Rack adjustment is provided for horizontal and vertical setting of the cutter head. A vertical adjustment of 2¼in and a horizontal adjustment of up to 4in can be made to the head, which can also be inclined on the arm up to 45 deg. for bevel cutting. The makers state that in straight line cutting a ¼in plate can be cut at a speed of 130ft per hour with a ⅛in nozzle, or a 2in plate at 40ft per hour with a ⅛in nozzle.

Nickel Alloy Spring Materials.—In addition to the usual requirements of adequate mechanical strength, springs must often be used in conditions which add further problems in specifying the material which will give the required properties. Such requirements may include resistance to corrosion to minimise failure due to corrosion-fatigue, or resistance to high-temperature conditions. Sometimes a special characteristic is required such as a-magnetism at temperatures in the sub-zero range, or low or high electrical or thermal conductivities; sometimes a combination of characteristics is required, as, for instance, in springs for accurate instruments, where low thermal expansion and zero thermo-elastic coefficients are desirable. Such properties and characteristics are available in the wide range of high-nickel alloys and a recent publication, *Nickel Alloy Spring Materials*, issued by Henry Wiggin and Co., Ltd., presents in convenient form data to assist the designer to make the correct selection of materials. First published two years ago, this revised edition of the book now contains data on Nimonic 90, an alloy stated to be particularly suitable for springs operating at high temperatures.

Industrial and Labour Notes

Railway Wages

The railway unions have accepted the offer of a 6 per cent increase in wages and salaries which was made a fortnight ago by the British Transport Commission. The 6 per cent, which includes the 4s. a week increase awarded at the beginning of December on the recommendation of the Railway Staff National Tribunal, dates from January 24th.

The National Union of Railwaymen, however, has expressed its disappointment about the Transport Commission's latest offer. It has stated that its acceptance has been given on the understanding that the offer is in the nature of an "interim settlement" whilst the Transport Commission and the unions proceed with an examination of the whole wages structure and an investigation of the standard rates of pay. The cost of the increases to those directly concerned has been estimated at about £12,500,000 a year, and the Transport Commission has already intimated that the 10 per cent increase in freight charges, for which it has applied, does not provide for any additions to wages beyond the 4s. a week already in operation.

Freight Charges

The Association of British Chambers of Commerce has sent a memorandum to the Minister of Transport urging him to exercise his powers under the Transport Act, 1947, to prevent a further substantial increase in railway freight charges. The memorandum expresses the Association's conviction that further advances in the wages of railway staff should be related to increased efficiency and the transfer of redundant railway personnel to other branches of industry and commerce.

The main point in the Association's opposition to a further increase of 10 per cent in freight charges is that it would do no more than continue the spiral of operating costs chasing charges and would not, therefore, solve the railways' economic problem. The memorandum says that "whether the Commission is the cause or the victim the fact remains that there exists an inflationary spiral, in which rises in the prices of coal, iron and steel invariably follow advances in freight charges."

The memorandum calls upon the Government to set up a working party representative of the Government, the Transport Commission, trade unions and transport users to investigate the urgent economic problems of British Railways "in a modern setting" and to reach agreed solutions. Some salient factors which should predominate in such an inquiry, the memorandum says, are the possible under-utilisation of rail carrying capacity and the existence of a surplus which can only be justified on national strategic or social, rather than economic, grounds; the achievement of economies in operation through the modernisation, reorganisation and streamlining of the railway system, and the whole question of the capitalisation of British Railways.

Changes in Wage Rates

The changes in wage rates which were reported to the Ministry of Labour as becoming effective in December last in the United Kingdom resulted in an aggregate increase of about £152,000 in the weekly full-time wages of 736,000 workpeople, and in a decrease aggregating about £120 for 2500 people. The decreases occurred under sliding scale arrangements based on the index of retail prices.

The Ministry of Labour says that over the whole of last year there was an increase in the average level of weekly wage rates of about 3 per cent, compared with about 6 per cent in the preceding year and 11 per cent in 1951. The index of weekly wage rates (June, 1947=100) stood at 138 for all workers at the end of last December, compared with 134 a year earlier. It has also been calculated that during last year about 9,000,000 workpeople received increases in wages aggregating nearly £2,500,000 a week, and it must be remembered that as the year ended there were a number of wage claims still outstanding.

Surveying the principal changes in wage rates last year, the Ministry shows that in the group of industries classified generally as "engineering, shipbuilding, electrical goods, and vehicles" about 149,000 workers received weekly wage increases aggregating £41,900, against £1,168,900 received by 2,975,500 workers in the same industries during the preceding year. In coal mining, the increase of 6s. in the national weekly minimum wage and other consequential increases, which were made last February, meant that 462,000 workers received additions to their weekly wages aggregating £129,700. In transport and communication, 898,000 workers last year received increases amounting to £226,500 a week. This, of course, included the 4s. a week increase in December to adult male workers employed by British Railways and proportional increases made to adult female and juvenile employees.

Industrial Production

The Central Statistical Office of the Treasury has estimated the index number of industrial production (1948=100) at 132 for all industries in November last, compared with 129 in October. The numbers for the corresponding months of 1952 were 123 in November and 119 in October. Taking the manufacturing industries alone, the index number for last November has been estimated at 134, compared with 124 in November, 1952, whilst in mining and quarrying the estimate for November last is 120, against 117 a year earlier. The Treasury says that information so far received indicates that the index for all industries in December may be 120 or 121, compared with 112 in December, 1952. It also says that the estimate for the whole of 1953 is 120, compared with 114 for 1952 and 117 for 1951.

Management and Unions

On Thursday of last week, Mr. Graham Hutton spoke at a meeting in Manchester which was organised by the British Productivity Council. In the course of his address he claimed that any recipe for raising productivity must start with management, and went on to say that whilst the best British management would equal the best anywhere, the average level seemed to be lower than the average in countries which had outstripped Britain. British management, Mr. Hutton asserted, needed to become more of a professional skill studied and learned in the firm and outside it. He thought that management should be more "on its toes" in the sense of being more enterprising, venturesome and pioneering in the application of new methods.

In the trade union world, as in management, Mr. Hutton continued, the chief problem was to raise the average level of understanding of modern economic problems, whether the workplace was privately or publicly owned, and then to approach those problems with fresh minds. The unions to-day, Mr. Hutton observed, did not stand to gain half as much from the old-fashioned ways of negotiating and bargaining as they could now gain from the far better armoury of detailed argument on accountancy figures, work study calculations, work-load figures and other "experts' weapons."

Production and Distribution Censuses

Last week, the President of the Board of Trade, Mr. Peter Thorneycroft, was questioned in Parliament as to the cost and value of the censuses of production and distribution. In a written reply, the President stated that the present cost of the annual census of production, as required by the Statistics of Trade Act, 1947, was about £175,000. The total cost of work on the first census of distribution, which began in 1949 and, apart from collation and publication, was completed by the end of 1951, would be about £710,000. It was essential, Mr. Thorneycroft added, that the cost of any such work should be justified by the benefit that it brought to industry and the community. He had therefore appointed a committee, which included representatives of industry and commerce, to advise him on future policy about the taking of censuses of production and distribution. Among other matters, that committee would examine the uses to which the censuses were put.

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The Ministry of Labour's statistics about stoppages of work through industrial disputes in December last show the effect of the "token stoppage" on December 2nd of workers in the engineering and shipbuilding industries. Altogether, in December, 140 stoppages of work occurred, involving 1,080,500 workpeople and causing an aggregate loss of 1,115,000 working days. According to the Ministry's figures, 1,050,000 engineering and shipbuilding workers participated in the stoppage in December.

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Notes and Memoranda

Rail and Road

CAMPAIGN FOR MODERN ROAD COMMUNICATIONS.—The British Road Federation has published a booklet entitled "Cross That River," in which attention is drawn to the inadequacy of highway river crossings—both bridges and tunnels—throughout the country. Examples are given of existing bridges which are in need of replacement, and of various new projects, such as the Severn Bridge, construction of which has been deferred. The history of the various tunnel projects started before the war, and then suspended, is also noted. The Federation also held a luncheon on January 27th, where guests representing "trade, industrial and civic interests" were invited "to discuss the immediate resumption of work on the Dartford-Purfleet tunnel." The pilot tunnel was driven fifteen years ago and some £850,000 had been spent on the work. In the Federation's opinion a resumption of work on the project was long overdue.

ROAD ACCIDENTS.—Casualties on the roads of Great Britain in December reached a total of 20,972, nearly 14 per cent more than in December, 1952. These figures represent the largest percentage increase of any month in 1953 over the corresponding month in 1952 and the total is the highest December total for which the Ministry of Transport and Civil Aviation has records. The Ministry points out that in drawing comparisons it should be remembered that since 1934, when road accidents in December reached their previous highest recorded peak, traffic has increased and the number of vehicles has more than doubled. In the last twelve months alone vehicles have increased by nearly 400,000. There were 582 deaths from road accidents in December, 1953, an increase of 105 on December, 1952. These are provisional figures and subject to minor adjustments. Total road casualties for 1953, including the provisional figures for December, numbered 226,520, or nearly 9 per cent over the total for the previous year. The number of deaths was 5070, an increase of 364. The number of seriously injured during the year was 56,452 and the slightly injured 164,998; compared with 1952 the figures for these groups show increases of 6101 and 12,043, respectively.

Air and Water

MR. A. WARLEY.—We record with regret the death of Mr. A. Warley, which occurred suddenly on Friday of last week, at the age of sixty-two. Mr. Warley was the engine works manager of Smith's Dock, South Bank, Middlesbrough.

MR. R. B. WEALLANS.—It is with regret that we record the death of Mr. R. B. Weallans, which occurred suddenly last week. Mr. Weallans, who was nearly sixty-five, was the naval architect of the Burntisland Shipbuilding Company, Ltd., which he joined in 1939 and of which he has been a director since 1949.

COMMODORE OF UNION CASTLE LINE.—Last week Captain T. W. McAllen retired as commodore of the Union Castle fleet, and the commodore's burgee was transferred from the "Edinburgh Castle" to the "Pretoria Castle," which is now the company's flagship under the command of Captain G. H. Mayhew, the new commodore.

CHAMBER OF SHIPPING.—At a council meeting of the Chamber of Shipping of the United Kingdom, held on January 28th, Mr. J. C. Denholm was nominated as President for the current year and Mr. A. I. Anderson as Vice-President, while Mr. C. W. Aston, Sir Ronald Garrett, Sir J. Gibson Graham, The Honourable J. S. Maclay and Mr. R. S. MacTier were co-opted as members.

AERIAL PHOTOGRAPH LIBRARY.—A book containing a comprehensive index of the 100,000 pictorial air views taken by Aerofilms, Ltd., 29, Old Bond Street, London, W.1, has now been published. Over one-half of this film library consists of specially commissioned views of industrial sites, private houses, and other properties, the remainder having been taken of objects speculatively as being of general interest. The book is illustrated and can be obtained on request.

EAST COAST SEA DEFENCES.—In reply to Parliamentary questions on Monday last, the Parliamentary Secretary to the Ministry of Agriculture, Mr. G. R. Nugent, said that river boards had made outstanding progress with the reconstruction and improvements of the East Coast defences damaged by last year's floods. Work costing £24,000,000 had been undertaken and about £20,000,000 worth was already completed. The remainder should be finished before the end of this year. Mr. Nugent added that the need for further works would be considered in the light of the Waverley committee's report which, it was hoped, would be received before Easter.

LECTURE COURSE ON SHOCK WAVES.—In the programme of special university lectures on aeronautical engineering planned by the University of London, a course of four lectures has been arranged on the physics of shock waves. It is to be given at the Imperial College of Science and Technology on February 8th, 9th, 22nd and 23rd, each lecture starting at 5 p.m. The course is by Professor A. Kantrowitz, Professor of Engineering Physics at Cornell University. The syllabus is as follows: lecture I, origin and macroscopic properties; lecture II, internal structure, heat capacity lag effects; lecture III, chemical reactions and ionisation following shock waves, and lecture IV, ionisation and radiation effects. The lectures are addressed to students of the university and to others interested in the subject, and admission is free without tickets.

Miscellanea

CODES OF PRACTICE: No. 325, "FARM AND HORTICULTURAL ELECTRICAL INSTALLATIONS."—In last week's issue (p. 192) we incorrectly applied the Code No. 113.201 (instead of No. 325) to this publication.

TUNGSTEN ORE PRICES.—The Ministry of Materials has announced that as from January 28th its selling price for tungsten ores of standard 65 per cent grade and ordinary quality has been reduced as follows:—Wolframite from £8 5s. to £7 5s., and scheelite from £7 10s. to £7 per long ton unit, delivered consumers' works.

MR. J. K. MCCRAITH.—We have learned with regret of the death of Mr. John Kennedy McCraith, which occurred, suddenly, at Newcastle upon Tyne on January 21st. Mr. McCraith, who was fifty-eight, had been manager of lamp and lighting sales at the Newcastle office of the British Thomson-Houston Company, Ltd., since 1943. He joined the company in 1929.

SHEFFIELD METALLURGICAL ASSOCIATION.—At the annual general meeting of the Sheffield Metallurgical Association, which was held on January 26th, Mr. F. H. Saniter was installed as president. Mr. Saniter is director of research of the United Steel Companies, and in his presidential address, which followed his installation, he described the post-war expansion of his firm's research and development department.

NATIONAL INDUSTRIAL FUEL EFFICIENCY SERVICE.—Last week it was announced that Dr. W. Angus Macfarlane, of the Department of Scientific and Industrial Research, had been appointed general manager of the recently formed National Industrial Fuel Efficiency Service. At present, Dr. Macfarlane is director of the United Kingdom Scientific Mission in North America, in which appointment he is to be succeeded by Mr. H. J. Hadow.

OIL SEARCH IN PERSIAN GULF.—We are informed that the Anglo-Iranian Oil Company, Ltd., will begin underwater research in the Persian Gulf during this month. The work will be carried out from the "Calypso," commanded by Commandant J. Y. Cousteau. Deep boring equipment will take samples from beneath the sea bed, which will be examined by divers. The area to be investigated is off Abu Dhabi, where the D'Arcy Exploration Company holds a concession over 12,000 square miles.

APPROVAL OF DARTMOOR SITE FOR TELEVISION STATION.—After considering the proceedings of a local inquiry held last September, Mr. Harold Macmillan, Minister of Housing and Local Government, has granted permission to the B.B.C. to build a television station at Hessary Tor in the Dartmoor National Park, to serve Devon and Cornwall. The permission is subject to conditions regarding the siting of the mast and buildings, and the materials to be used. In addition, all cables serving the station must be buried; the approach road to the station must be fenced from the moor and surfaced with approved material, and the existing barrow on North Hessary Tor must not be disturbed until representatives of the Devonshire Association have had an opportunity to excavate it.

RECOMMENDED PRACTICE FOR ELECTRICAL INSTALLATIONS IN CARAVANS.—The Institution of Electrical Engineers, 2, Savoy Place, London, W.C.2, has published a memorandum "Recommended Practice for Electrical Installations in Caravans," which explains to what extent the *Regulations for the Electrical Equipment of Buildings* (the "Wiring Regulations") should be applied to caravans using mains electricity supply. The recommendations apply to trailer caravans taking supplies at voltages not exceeding 250V and they express the main requirements for safe operation. Both publications can be obtained from the address given above: the "Recommended Practice for Electrical Installations in Caravans" costs 1s. and the "Wiring Regulations," upon which the recommended practice is based, costs 5s. (paper covers) or 7s. 6d. (cloth covers).

Personal and Business

MR. B. H. BULANTY has succeeded Mr. H. Vezey Strong as chairman of Silentbloc, Ltd., Victoria Gardens, London, W.11.

MR. JOHN GRAY has been appointed managing director of Brentford Transformers, Ltd., Kidbrooke Park Road, London, S.E.3.

B.S.A. TOOLS, Ltd., states that, owing to postal rearrangements, the address of its head office is now Mackadown Lane, Kitts Green, Birmingham, 33.

BRITISH INSULATED CALLENDER'S CONSTRUCTION COMPANY, Ltd., has moved into new offices at 30, Leicester Square, London, W.C.2 (telephone, Trafalgar 7777).

LONDON TRANSPORT states that Mr. R. C. Hider has been appointed divisional superintendent, "A" division, in the department of the operating manager (railways).

THE PRESIDENT OF THE BOARD OF TRADE has appointed Mr. Maynard Jenour a director and vice-chairman of the board of Wales and Monmouthshire Industrial Estates, Ltd.

MR. A. D. JOHNSON has relinquished his position with the Ellis Research and Testing Laboratories to join the consulting firm of Dames and Moore, 34, Smith Square, London, S.W.1.

MR. J. N. MCHATTIE, A.M.I.Mech.E., has been appointed technical officer of the Society of Motor Manufacturers and Traders, in succession to the late Mr. Harold Clutterbuck.

THE BRITISH THOMSON-HOUSTON COMPANY, Ltd., announces the appointment of Mr. G. Lloyd Jones as manager of the Cardiff office, in succession to Mr. A. F. MacCarthy, M.I.E.E., who is retiring.

MR. HAMISH FERGUSON has retired from the secretaryship of the Diesel Engine Users Association and is continuing his consulting practice from 2, Northcote Avenue, Ealing, London, W.5 (telephone, Ealing 5482).

INTERNATIONAL HARVESTER COMPANY OF GREAT BRITAIN, Ltd., 259, City Road, London, E.C.1, announces the appointment of Mr. David C. Haney as director of sales. Mr. D. J. McIntosh becomes manager of sales and Mr. R. R. King assistant manager of sales.

AIR COMMODORE SIR FRANK WHITTLE has taken up an appointment with the Bataafsche Petroleum Maatschappij of The Hague, to act as consultant in the field of mechanical engineering relative to the development of techniques and equipment in the petroleum and chemicals-from-petroleum industries.

THE FRASER AND CHALMERS WORKS OF THE GENERAL ELECTRIC COMPANY, Ltd., announces the retirement of Mr. Oliver Thomas from the position of manager of the materials handling department. Mr. Thomas has been in the company's service for nearly fifty-two years. Mr. B. S. Pelton has succeeded Mr. Thomas.

THE DAVID BROWN GROUP has established a new branch office at 2693 (3a), Alving Room Court, Oakland, 5, California. Mr. C. A. Glover is the manager, with Mr. W. W. Nicholson and Mr. F. G. Hendy as sales and service managers respectively. The new branch is attached to David Brown (Canada), Ltd.

THE BIRMINGHAM WELDING COMPANY, Ltd., will in future be known as Birwelco, Ltd. This change coincides with the formation of a subsidiary company entitled Brown Fintube (Great Britain), Ltd., which will manufacture under licence American Brown Fintube products. The address of Birwelco, Ltd., and its subsidiary is Chester Street, Aston, Birmingham, 6.

LONDON MIDLAND REGION OF BRITISH RAILWAYS has announced the following appointments:—Mr. F. Fawcett, A.M.I.C.E., district engineer, St. Pancras; Mr. R. S. Pedder, A.M.I.E.E., principal assistant (electrical) in the mechanical and electrical engineer's department; Mr. E. H. C. Shorto, coal supplies officer in the motive power superintendent's department at Derby.

Contracts

DAVID BROWN AND SONS (HUDDERSFIELD), Ltd., has received from Mirrlees Watson Company, Ltd., orders covering the supply of twelve turbine reduction gear units for new sugar plant commissioned by Campania Anonima, Venezuela.

METROPOLITAN-VICKERS ELECTRICAL COMPANY, Ltd., has received an order for the electrical equipment of a 40in blooming mill at the Cleveland Works of Dorman Long and Co., Ltd. The mill will have a 5000 h.p. twin-motor drive, one motor being coupled directly to the top mill roll and the other to the bottom roll, an arrangement which dispenses with the need for the conventional mill pinion gearbox. The equipment will comprise two 2500 h.p., 40/90 r.p.m. motors; a Ward-Leonard motor-generator set comprising two 2000kW generators, a 150,000 h.p. sec. flywheel and a 4000 h.p., 11kV slipring induction motor; a main exciter set, and special quick response auxiliary exciters for use in conjunction with Ward-Leonard control equipment. The flywheel and induction motor will operate in conjunction with an automatic liquid slip regulator to reduce the electrical peak loads on the supply system. The main machines will be force-ventilated with filtered air. The control scheme, specially developed to ensure rapid starting and reversal of the main motors, will employ metadyne high response exciters. Provision is made for automatic load limiting, individual speed adjustment of the motors, and voltage compensation on the generators.

CONTRACTS have been placed by the British Electricity Authority during the past month for power stations, transforming stations and transmission lines amounting in the aggregate to £6,263,794. The principal contracts include: Brighton "B" power station, Shoreham Harbour development works (Peter Lind and Co., Ltd.) and Shoreham Harbour lock gates (Head, Wrightson and Co., Ltd.); Tilbury power station, foundation for second half of station (Holloway Brothers (London), Ltd.); Castle Donington power station, near Derby, foundations and aqueducts (Taylor Woodrow Construction, Ltd.). structural steelwork (Sir Wm. Arrol and Co., Ltd.), and 415V contactor control gear and associated equipment (Contactor Switchgear, Ltd.); Willington "A" power station, near Derby, one 120MVA generator transformer (English Electric Company, Ltd.); Nottingham power station, coal handling plant (International Combustion, Ltd.); Hams Hall power station, near Birmingham, railway sidings (Wm. Jones, Ltd.); Bold "A" power station, St. Helens, high-pressure pipework and valves (Alton and Co., Ltd.); Connah's Quay power station near Flint, superstructure (J. Gerrard and Sons, Ltd.); Ince power station, near Ellesmere Port, auxiliary switchgear (English Electric Company, Ltd.); York power station, two 100,000 lb per hour boilers (Richardsons Westgarth (Hartlepool), Ltd.); Carrington power station, near Manchester, circulating water pipework (T. B. Pearson and Sons, Ltd.), and Huncoat power station, Accrington, one 305,000 lb per hour boiler and structural steelwork (Simon-Carves, Ltd.).

British Patent Specifications

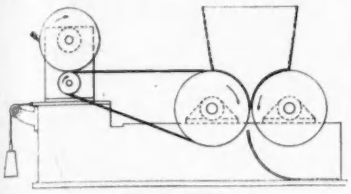
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 2s. 8d. each.

AGRICULTURAL ENGINEERING

701,176. August 16, 1951.—GRINDING MILLS, Charles Goodall, Silverhill, Barton-under-Needwood, Burton-on-Trent.

The invention provides a machine which will reduce vegetable matter to a finely divided state by grinding action, and which can also be employed for pulverising minerals or other solid substances. As the drawing shows, a pair of pulleys are provided for the purpose of carrying an endless abrasive band. A feed roller, the same diameter as the larger pulley, is arranged adjacent to it, and a hopper is situated



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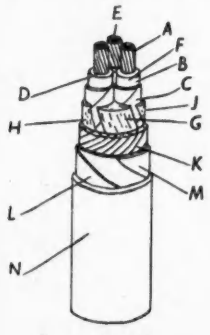
over the two pulleys. A collecting roller is mounted above the smaller pulley. The material from the hopper falls between the pulleys, and by the action of the abrasive belt is reduced to a finely divided condition, the stems or coarse fibres being caught by the chute below the feed roll, and delivered to the discharge position. The finely divided material adheres to the abrasive band and reaches the collecting roller from which it is removed by the scraper shown. It can also be removed from the underside of the abrasive band.—*December* 16, 1953.

ELECTRICAL ENGINEERING

701,309. July 17, 1951.—ELECTRIC CABLES EXPOSED TO FLAME ACTION, Societe Industrielle de Liaisons Electriques, 64 bis, rue de Monceau, Paris (Seine). (*Inventor: Andre Noirclerc.*)

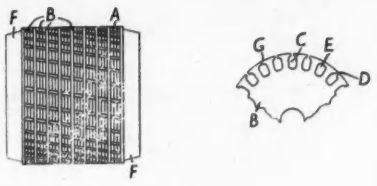
The object of the invention is to provide a cable which can continue to function in or near a fire. As shown in the drawing, the conducting core *A* is covered with a non-inflammable covering *B* of magnesia agglomerated by a low proportion of an elastic or plastic material, such as the polymers of isoprene, chloroprene, isobutylene, employed alone or in admixture with chlorinated organic products, such as chloronaphthalene or pentachlorodiphenyl. This covering is covered with a woven ribbon *C* of a flame-resisting product, such as silicates of calcium or magnesium or silico-aluminates. The three conductors *D*, *E* and *F* are intertwisted with three packings *G*, *H* and *J* of asbestos strands impregnated with a non-inflammable material. The assembly is covered with a wrapping *K* of asbestos impregnated with a non-inflammable material and then covered with an armouring constituted by two steel ribbons *L* and *M* wound helically with the same pitch, the space between the two adjoining turns of the first ribbon being covered by the second ribbon. Finally this armouring is covered with a sheath *N* of a product which does not spread fire, having a base of polyvinyl chloride or polychloroprene. Fire test results are also inluded in the specification.—*December* 23, 1953.



No. 701,309

699,987. September 4, 1951.—DYNAMO-ELECTRIC MACHINES, The British Thomson-Houston Company, Ltd., Crown House, Aldwych, London, W.C.2.

The invention aims at providing an improved rotor construction to ensure satisfactory and noiseless operation of the motor and simplify manufacture. In the drawings there is shown a squirrel-cage rotor *A* formed of a number of laminations *B*. The laminations are provided with slots *C* for receiving the squirrel-cage bars of the rotor, these slots having openings *D*. As shown, the laminations are also provided with a number of totally closed slots *E*. The closed slots are interleaved between the open slots across the axial length of the rotor. After the laminations have been stacked, squirrel-cage bars are arranged in the slots *C* and *E* of the laminations *B*, as by casting, and end rings *F* complete the squirrel-cage winding. The utilisation of both open and closed slots in the same rotor effectively reduces the average thickness of the bridge section *G* over the rotor bars from that which would be provided if the rotor was formed completely of totally enclosed



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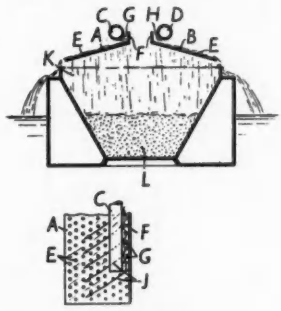
slot laminations. The ratio between the number of totally closed slots and the number of open slots also determines the equivalent bridge thickness, which can be simply adjusted to any desired value by varying the ratio. It has been found that a ratio of from 50 per cent to 85 per cent open slots will provide a satisfactory construction in which high and low-frequency noise are at a minimum and that in rotors used in hermetic refrigerator compressor assemblies a ratio of three open slots to one closed slot produce the best results. Modified arrangements of the open and closed slots grouped together are also shown in the specification.—*November* 18, 1953.

MARINE ENGINEERING

701,300. April 23, 1951.—MEANS FOR FILLING HOLDS WITH DREDGED MATERIAL, Co-öperatieve Vereniging Mineraal Technologisch Institut u.a., 209, Oostsingel, Delft, The Netherlands.

The invention relates to a method for loading hopper barges with dredged material particularly fine sand, by means of one or more delivery pipes with discharge openings, and screens between these openings and the hold. According to the drawing, screens *A* and *B* which slope downwards slightly in the outward direction are provided between the delivery pipes *C* and *D*. The apertures in the plates are indicated at *E*. The inner marginal portions *F* of the screens are bent up. The discharge openings *G* and *H* distributed along the pipes are



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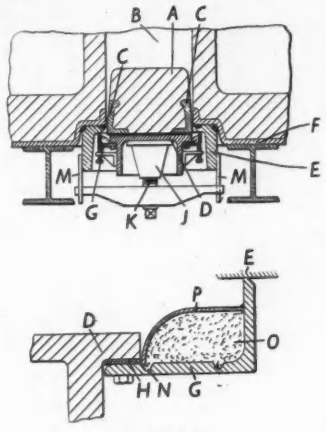
directed into the angle between the screen walls *A* and the marginal portions *F*, and also at an inclination in a forward or rearward direction. As a result the aqueous suspension of dredged material rebounds in a number of jets *J* from the marginal portion *F* of each screen (see the lower view) and is distributed in the form of a thin layer over the major portion of the screens, whereby extensive initial separation of the mixture is carried out. A proportion of the separated water passes over the whole width of the screens and back into the sea or river. The more concentrated mixture falls, in the form of a number of small streams, through the small apertures *E* into the hold *K*. These small streams are not powerful enough to produce disturbing currents in the water in the hold. The previously formed mass of dredged solids *L* thus remains undisturbed. This favours the further deposit of solids and, furthermore, the loss of the hitherto relatively large amount of the solids washed overboard is prevented. —*December* 23, 1953.

COKE OVENS

701,868.—January 1, 1952.—SELF-SEALING DOOR, Heinrich Koppers Gesellschaft Mit Beschrankter Haftung, Moltkestrasse 29, Essen, Germany.

The invention relates to self-sealing doors for coke ovens with a resilient angular sealing frame. As shown in the drawing, the door comprises a refractory plug *A*, which extends into the oven chamber *B*. The refractory plug is secured by girders *C* to the door body *D*. The door frame *E* is sealed to the metallic reinforcement *F* of the oven. An L-section sealing frame *G* is fixed to the door body *D* with an interposed asbestos packing *H*. The door body carries a bearing *J* on which is a latch bolt *K*, with a latch at its free end; when the door is closed the latch engages behind hooks *M* fixed to the door frame. As the lower view shows, the sealing frame



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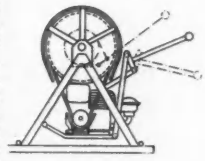
G has unequal arms, the shorter of which abuts the sealing surface of the door frame *E* when the door is closed. The other arm of the sealing frame is provided with longitudinal grooves *N*, which have a depth sufficient to provide the arm with the desired degree of flexibility. Preferably the sealing frame *G* is protected from the heat radiating from the oven chamber *B* by insulation *O* of glass wool or the like, this insulation being enclosed in a sheet metal frame *P*. —*January* 6, 1954.

CRANES AND LIFTING DEVICES

701,083. April 29, 1952.—MOTOR WINCH, Raphael Wormser and Julius Wormser, trading as Joseph Wormser Sohne, Freigutstrasse 10, Zurich, Switzerland.

As the drawing shows, the motor winch is arranged so that the engine driving the winch is mounted on a cradle and its weight tensions the belt. A multiple "V"-belt drive is used, with belt guides for the driving and driven wheels. By moving the operating lever shown to the right of the drawing, the cradle is raised and the belts are lifted from both pulleys, thus slackening the belt drive. After a certain degree of lift by the lever, the belts lie against the apex of their guides and on further lifting are raised out of the pulley grooves and bear against both guides so that when the engine is running idle they are completely disengaged from the pulleys. The construction, it is claimed, gives a high degree of protection to the "V"-belts and results in easy return running of the winch drum.—*December* 16, 1953.

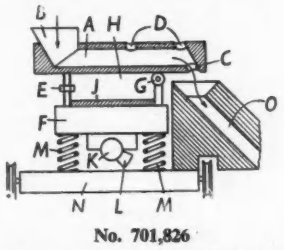


No. 701,083

METALLURGY

701,826.—August 9, 1951.—THE PRODUCTION OF STEEL, Bochumer Verein für Gussstahlfabrikation Aktiengesellschaft, of Stahlhauserstrasse, 20, Bochum, Germany.

According to the invention high-grade steel, immediately before being cast into a mould, is conducted through a device subjected to vibration. This helps to homogenise the steel by causing the heavier constituents, such as iron, carbon, manganese, or



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silicon, to be intensively and molecularly mixed, so that a much more uniform structure is produced and maintained up to solidification. At the same time, much of the light gaseous constituents of the steel is driven out. The frequency and amplitude of the

vibrations may be varied according to the composition of the steel. In the drawing of the device *A* represents the flow pipe with a filling hopper *B* and discharge branch *C* and holes *D* for the escape of the discharged gas. The flow pipe is connected through *E* with a vibratory table *F*, so as to be movable about a pivot *G* in order to regulate the speed of flow. Between the flow pipe and the table is an air gap *H* and supplementary heat insulator *J*. Mounted underneath the table *F* is a rotating shaft *K* with an unbalanced weight *L*. The vibratory table is connected through springs *M* with a crab *N* which runs on wheels across a travelling platform. The crab *N* also has rigidly connected to it a discharge *O* by which the steel from the flow pipe *A* is conducted into the casting mould. The complete assembly runs on rails over the casting pit.—*January* 6, 1954.

Launches and Trial Trips

BOW SANTOS, cargo ship ; built by Hall, Russell and Co., Ltd., for Skibsaksjeselskapet Hassel, Norway ; length between perpendiculars 395ft, breadth moulded 58ft, depth moulded to shelter deck 37ft 4in, deadweight 8010 tons in 25ft 1in summer draught ; five holds, derricks include one to lift 25 tons, electric deck machinery ; twelve passengers ; Wilton-Fijenoord-Doxford oil engine, five cylinders, 5500 b.h.p. at 112 r.p.m., three 150kW diesel-driven generators. Trial, January 14th.

REGENT ROYAL, oil tanker ; built by the Blythswood Shipbuilding Company, Ltd., for Trinidad Leaseholds, Ltd.; length between perpendiculars 487ft, breadth 65ft 6in, depth moulded 35ft 4in, deadweight 14,500 tons ; twenty-four cargo oil tanks, two pump rooms, four steam-driven pumps totalling 1500 tons per hour ; Rowan-Doxford two-stroke, opposed-piston oil engine, four cylinders, 670mm diameter by 2320mm combined stroke, 4500 b.h.p., two single-ended horizontal multitubular boilers, service speed 14 knots. Launch, January 18th.

BORDER FUSILIER, oil tanker ; built by R. and W Hawthorn, Leslie and Co., Ltd., for the Lowland Tanker Company, Ltd.; length overall 547ft, breadth moulded 69ft 6in, depth moulded 37ft 6in, deadweight 16,100 tons ; twenty-seven oil cargo tanks, two pump rooms ; Hawthorn-Doxford oil engine, six cylinders, 670mm diameter by 2320mm combined stroke, 6400 b.h.p. at 115 r.p.m., two 150kW diesel-driven generators, one 75kW steam-driven generator. Launch, January 19th.

LOCH GOWAN, cargo liner ; built by Harland and Wolff, Ltd., for the Royal Mail Lines, Ltd.; length between perpendiculars 470ft, breadth moulded 68ft, depth moulded to shelter deck 41ft, gross tonnage 9650 ; two steel decks, eight watertight compartments, five cargo holds, derrick complement includes one to lift 30 tons, electric deck machinery, one 600kW turbine-driven generator, two 300kW diesel-driven generators ; one set of triple-expansion, all-reaction, double-reduction geared turbines, 10,500 s.h.p. at 112 r.p.m. of propeller, steam supplied at 525 lb per square inch and 825 deg. Fah. by two Foster-Wheeler boilers. Launch, January 19th.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases, the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

BRITISH INSTITUTION OF RADIO ENGINEERS

Wed., Feb. 10*th.*—N.E. SECTION : Neville Hall, Westgate Road, Newcastle upon Tyne, "Some Aspects of Micro-Wave Aerial Design," J. Bilbrough, 6 p.m.

Wed., Feb. 17*th.*—LONDON SECTION : School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, W.C.1, "Electronics in Film Making," W. D. Kemp and B. R. Greenhead, 6.30 p.m.

CLEVELAND INSTITUTION OF ENGINEERS

Mon., Feb. 15*th.*—Cleveland Scientific and Technical Institution, Corporation Road, Middlesbrough, "The New Blast-Furnace and Ancillary Equipment at Shotton," F. Jones, 6.30 p.m.

INCORPORATED PLANT ENGINEERS

Mon., Feb. 8*th.*—DUNDEE BRANCH : Mathers Hotel, Dundee, "Hydraulics : General Principles and Application," "Introduction to the Heat Engine," "The Diesel Generator as a Composite Heat and Power Uunit," "The Grangemouth Project," 7.30 p.m.

Wed., Feb. 10*th.*—E. MIDLANDS BRANCH : Demonstration Theatre, Gas Board Showrooms, Parliament Street, Nottingham, "Air Conditioning," A. Peel, 7 p.m.

Thurs., Feb. 11*th.*—N.E. BRANCH : Roadway House, Oxford Street, Newcastle upon Tyne, "Metallurgy," J. Rolston, 7 p.m.

Mon., Feb. 15*th.*—MERSEYSIDE AND N. WALES BRANCH : Radiant House, Bold Street, Liverpool, "Mechanical Service Equipment in a Medium-Sized Chemical Factory," D. W. Evans, 7.15 p.m.

Tues., Feb. 16*th.*—KENT BRANCH : Bull Hotel, Rochester, "Steam Storage," E. G. Ritchie, 7 p.m.——S. WALES BRANCH: Mackworth Hotel, Swansea, "The Selection and Maintenance of Ball and Roller Bearings," 7.30 p.m.

Wed., Feb. 17*th.*—GLASGOW BRANCH : Scottish Building Centre, 425/427, Sauchiehall Street, Glasgow, C.2, "Industrial Lighting," F. H. Fielder, 7 p.m.——WESTERN BRANCH : Grand Hotel, Bristol, "The Generation of Industrial Power from Process Steam," E. G. Ritchie, 7.15 p.m.

Thurs., Feb. 18*th.*—BLACKBURN BRANCH : Grosvenor Hotel, Lord Street, Blackburn, "Fire Protection for Industrial Buildings," A. Jackson, 7.30 p.m.

INSTITUTE OF MARINE ENGINEERS

Tues., Feb. 9*th.*—85, Minories, London, E.C.3, A Symposium, "Some Interesting Ship and Machinery Defects : Their Investigation and Cure," 5.30 p.m.

INSTITUTE OF METALS

Mon., Feb. 8*th.*—SCOTTISH LOCAL SECTION : Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, "Some Practical Hints on the Production of Non-Ferrous Castings," William Dunlop, 6.30 p.m.

INSTITUTE OF NAVIGATION

Fri., Feb. 19*th.*—Royal Geographical Society, 1, Kensington Gore, London, S.W.7, "The Requirements for Marine Pilotage," L. W. Akerman and R. F. Hansford, 5 p.m.

INSTITUTE OF PETROLEUM

Wed., Feb. 10*th.*—26, Portland Place, London, W.1, "Accident Prevention," T. T. Maclean, 5.30 p.m.

INSTITUTE OF REFRIGERATION

Tues., Feb. 16*th.*—Institution of Mechanical Engineers, Storey's Gate, St. James's Park, London, S.W.1, "Modern Methods of Oxygen Production," A. M. Clark, 5.30 p.m.

INSTITUTE OF TRANSPORT

Mon., Feb. 8*th.*—Jarvis Hall, 66, Portland Place, London, W.1, Brancker Memorial Lecture, "The Impact of the Gas Turbine on Civil Aviation," Sir Miles Thomas, 5.45 p.m.

Mon., Feb. 15*th.*—METROPOLITAN SECTION : 80, Portland Place, London, W.1, Symposium on "London Transport," F. G. Maxwell and J. B. Burnell, 5.30 p.m.

INSTITUTE OF WELDING

Thurs., Feb. 11*th.*—SLOUGH SECTION : Community Centre, Farnham Road, Slough, Bucks, "Resistance Welding in Production," E. A. Whittaker, 7.30 p.m.——S. LONDON BRANCH : 2, Savoy Hill, London, W.C.2, Discussion on "Training and Testing of Arc Welders," opened by A. E. Swetnam, B. E. Lambie and A. B. Tompkins, 6.30 p.m.

INSTITUTION OF BRITISH AGRICULTURAL ENGINEERS

Tues., Feb. 16*th.*—Institution of Electrical Engineers, Savoy Place, London, W.C.2, "Mechanisation of Bracken Eradication," G. Henderson, 2.15 p.m.

INSTITUTION OF CIVIL ENGINEERS

Tues., Feb. 9*th.*—PUBLIC HEALTH MEETING : Great George Street, Westminster, London, S.W.1, "Public Health Engineering in Developed and Underdeveloped Countries," R. F. Burden, 5.30 p.m.

Thurs., Feb. 11*th.*—N.W. ASSOCIATION, STUDENTS' MEETING : Engineers' Club, Albert Square, Manchester, Discussion on "The First Years of Professional Employment," 6.30 p.m.——MIDLANDS ASSOCIATION : James Watt Memorial Institute, Great Charles Street, Birmingham, "Some Problems in Railway Civil Engineering Maintenance," A. H. Cantrell, 6 p.m.

Tues., Feb. 16*th.*—ORDINARY MEETING : Great George Street, Westminster, London, S.W.1, "History and Construction of the Foundations of the Asia Insurance Building, Singapore," W. J. R. Nowson, 5.30 p.m.

Thurs., Feb. 18*th.*—N.W. ASSOCIATION : Engineers' Club, Albert Square, Manchester, 2, Dugald Clerk Lecture, "Plant for the Construction and Maintenance of Highways," R. R. W. Grigson, 6.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

Mon., Feb. 8*th.*—INFORMAL MEETING : Savoy Place, London, W.C.2, Discussion on "Will it be Possible to Abolish Meters Entirely ?" opened by H. S. Petch and M. Whitehead, 5.30 p.m.

Tues., Feb. 9*th.*—S.E. SCOTLAND SUB-CENTRE : Carlton Hotel, North Bridge, Edinburgh, "Fluorescent Discharge Circuits and Operating Problems," J. Cates, 7 p.m.——N. MIDLAND CENTRE : British Electricity Authority, 1, Whitehall Road, Leeds, 1, "Special Effects for Television Studio Production," A. M. Spooner and T. Worswick, 6.30 p.m.

Wed., Feb. 10*th.*—N. SCOTLAND SUB-CENTRE : Caledonian Hotel, Aberdeen, "Fluorescent Discharge Tube Circuits and Operating Problems," J. Cates, 7.30 p.m.——RADIO SECTION : Savoy Place, London, W.C.2, "Basic Ground-Wave Propagation Characteristics in the 50-800 Mc/s Band," J. A. Saxton ; "Gound-Wave Field Strength Surveys at 100 and 600 Mc/s," J. A. Saxton and B. N. Harden, 5.30 p.m.

Thurs., Feb. 11*th.*—EXTRA MEETING : Savoy Place, London, W.C.2, "A Short Modern Review of Fundamental Electromagnetic Theory," P. Hammond, 5.30 p.m.——N. SCOTLAND SUB-CENTRE : Royal Hotel, Dundee, "Fluorescent Discharge Tube Circuits and Operating Problems," J. Cates, 7 p.m.——LONDON STUDENTS' SECTION : Public Library, Chelmsford, "Industrial Consumer Installation Practice," J. J. Peacock, 7 p.m.

Mon., Feb. 15*th.*—EDUCATION DISCUSSION CIRCLE : Savoy Place, London, S.W.1, Discussion on "The Teaching of the Subject of Insulating Materials," opened by Willis Jackson, 6 p.m.

Tues., Feb. 16*th.*—FARADAY LECTURE : Central Hall, Westminster, London, S.W.1, "Electro-Heat and Prosperity," O. W. Humphreys, 6 p.m.——LONDON STUDENTS' SECTION : R.E.M.E. Training Centre, Hazebrouck Barracks, Arborfield, Berks, "Development of Electrical Aids in A.A. Gunnery," D. H. A. Huddart, 6.30 p.m.——S.E. SCOTLAND SUB-CENTRE : Carlton Hotel, North Bridge, Edinburgh, Discussion on "Town Planning with Reference to the Electrical Engineer," opened by T. T. Hewitson, 7 p.m.——N. MIDLAND CENTRE : British Electricity Authority, 1, Whitehall Road, Leeds, 1, "Electricity in Farm Crop Drying," C. A. Cameron Brown and P. G. Finn-Kelcey, 6.30 p.m.

Thurs., Feb. 18*th.*—UTILIZATION SECTION : Savoy Place, London, W.C.2, "Electronic Motor Control," A. O. Dalton ; "Arch-Quenching Circuits," B. H. Stonehouse ; "A Survey of the Principles of the Contact Rectifier," D. R. Smith, 5.30 p.m.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND

Tues., Feb. 9*th.*—39, Elmbank Crescent, Glasgow, "Electronic Instruments Developed for Marine Turbine Research," J. Hare and R. B. Conn, 6.45 p.m.

INSTITUTION OF LOCOMOTIVE ENGINEERS

Wed., Feb. 10*th.*—Institution of Mechanical Engineers, Storey's Gate, St. James's Park, London, S.W.1, "The Measurement of Train Resistance," H. I. Andrews, 5.30 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

Mon., Feb. 8*th.*—DERBY A.D. CENTRE : Midland Hotel, Derby, "The Jaguar Engine," W. M. Heynes, 7.15 p.m.——LUTON A.D. CENTRE : Town Hall, Luton, "Tyre Development," T. Joy and D. C. Hartley, 7.30 p.m.

Wed., Feb. 10*th.*—E. MIDLANDS BRANCH : The University Nottingham, "Three Dimensional Stress Analysis by Photo-Elastic Methods," H. Fessler, 7.30 p.m.

Thurs., Feb. 11*th.*—YORKSHIRE BRANCH : The University, Leeds, "Recent Developments in Constructional and Tool Steels," E. Johnson, 7 p.m.

Fri., Feb 12*th.*—GENERAL MEETING, APPLIED MECHANICS GROUP : Storey's Gate, St. James's Park, London, S.W.1, Third Report of the Pipe Flanges Research Committee, presented by A. E. Johnson, 5.30 p.m.

Mon., Feb. 15*th.*—SCOTTISH A.D. CENTRE : Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, "Automobile Engineering," Mr. Kemp, 7.30 p.m.

Tues., Feb. 16*th.*—EASTERN BRANCH: Dujon Restaurant, Bedford, Presidential Address, A. Roebuck, 7.30 p.m.——WESTERN BRANCH : Grand Hotel, Bristol, "Relaxation Methods : A Retrospect," Sir Richard Southwell, 7 p.m.

Wed., Feb. 17*th.*—N.W. BRANCH : Liverpool Engineering Society, 24, Dale Street, Liverpool, "High-Temperature Turbine Machinery for Marine Propulsion," T. W. F. Brown, 6 p.m.——YORKSHIRE BRANCH : Station Hotel, Hull, "Airships," Lord Ventry, 7.15 p.m.——N.E., A.D., CENTRE : The University, Leeds, "Combustion in Compression-Ignition Oil Engines," S. J. Davies 7.30 p.m.

Thurs., Feb. 18*th.*—MIDLAND BRANCH : James Watt Memorial Institute, Great Charles Street, Birmingham, Annual General Meeting, "High-Temperature Turbine Machinery for Marine Propulsion," T. W. F. Brown, 6 p.m.——N.W. BRANCH : Engineers' Club, Albert Square, Manchester, "An Investigation of Fretting Corrosion," K. H. R. Wright, 6.45 p.m.

Fri., Feb. 19*th.*—GENERAL MEETING : Storey's Gate, St. James's Park, London, S.W.1, "Production and Design," L. H. Leedham, 5.30 p.m.

INSTITUTION OF MINING AND METALLURGY

Thurs., Feb. 18*th.*—Geological Society, Burlington House, Piccadilly, London, W.1, Discussion on the "Present-Day Meaning Given to the Term 'Ore,'" "Production of Asbestos in South Africa," W. E. Sinclair, 5 p.m.

INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS

Tues., Feb. 9*th.*—ORDINARY MEETING : Institution of Electrical Engineers, Savoy Place, London, W.C.2, "Step-by-Step Auto-Exchange Maintenance in the U.S.A.," E. Hopkinson and J. Prescott, 5 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

Mon., Feb. 8*th.*—HALIFAX, YORKSHIRE AND SHEFFIELD SECTIONS : Grand Hotel Sheffield, "Some Recent Developments in Engineering," T. E. Allibone, 6.30 p.m.

Tues., Feb. 9*th.*—PETERBOROUGH SECTION : Grand Hotel, Peterborough, "Productivity," W. Coutts Donald, 7.30 p.m.——S. ESSEX SECTION : Public Library, Duke Street, Chelmsford, Joint Meeting with the Institute of Industrial Supervisors, 7.30 p.m.

Wed., Feb. 10*th.*—PRESTON SECTION : Victoria and Station Hotel, Preston, "Noise and Vibration in Industry," A. J. King, 7.15 p.m.

Thurs., Feb. 11*th.*—LEICESTER SECTION : Bell Hotel, Leicester, Annual General Meeting and Film, 7 p.m.——LONDON SECTION : Royal Empire Society, Northumberland Avenue, London, W.C.2, "Figures as an Aid to the Production Engineer," T. Whitwell, 7 p.m.——ROCHESTER AND DISTRICT SECTION : Sun Hotel, Chatham, "Metallurgical Control in the Hardening Shop," M. Glasby, 7.30 p.m.

Fri., Feb. 12*th.*—EASTERN COUNTIES BRANCH : Diocesan Hall, Tower Street, Ipswich, "The Structure of Production Management," M. Seaman, 7.30 p.m.——GLOUCESTER AND DISTRICT SECTION : Wheatstone Hall, Gloucester, "Some Applications of Automatic Controls in Industry," R. Parr, 7.15 p.m.——W. WALES SECTION : Central Public Library, Alexandra Road, Swansea, "Increased Productivity," H. O'Neill, 7 p.m.

INSTITUTION OF STRUCTURAL ENGINEERS

To-day, Feb. 5*th.*—WESTERN COUNTIES BRANCH : The University, Geology Lecture Theatre, Bristol, "The Industrial Architect and Engineer," J. E. Collins, 6 p.m.

Tues., Feb. 9*th.*—MIDLAND COUNTIES BRANCH : King's Hall, Queen Street, Derby, "Prestressed Concrete Framework for Liverpool University Medical School," E. Shepley, 7 p.m.——SCOTTISH BRANCH : Ca'doro Restaurant, Glasgow, "The Reconstruction of Portobello Power Station," C. M. Wilson, 6 p.m.

Thurs., Feb. 11*th.*—LANCASHIRE AND CHESHIRE BRANCH : College of Technology, Manchester, "Composite Action in Structures," F. G. Thomas, 6.30 p.m.

JUNIOR INSTITUTION OF ENGINEERS

To-day, Feb. 5*th.*—Townsend House, Greycoat Place, London, S.W.1, Films, "The Story of Steel," "Steel," "Great Achievement," introduced by P. Cameron, 7 p.m.

Mon., Feb. 8*th.*—N.W. SECTION : Engineers' Club, Albert Square, Manchester, "The Design and Construction of Special Electro-Mechanical Devices," F. E. Bancroft, 7.30 p.m.

Fri., Feb. 12*th.*—ORDINARY MEETING : Townsend House, Greycoat Place, London, S.W.1, "Steam Utilisation and Heat Conservation," Leonard Clegg, 7 p.m.

LIVERPOOL ENGINEERING SOCIETY

Wed., Feb. 10*th.*—24, Dale Street, Liverpool, "High-Temperature Steam and Gas Turbine Machinery for Marine Propulsion," T. W. F. Brown, 6 p.m.

LIVERPOOL METALLURGICAL SOCIETY

Thurs., Feb. 11*th.*—Liverpool Engineering Society, 24, Dale Street, Liverpool, "Diffusion in Metals," A. D. Le Claire, 7 p.m.

MANCHESTER ASSOCIATION OF ENGINEERS

To-day, Feb. 5*th.*—Engineers' Club, Albert Square, Manchester, "Some Notes on the Design and Construction of Large Aircraft," H. Rogerson, 6.45 p.m.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS

Fri., Feb. 12*th.*—Mining Institute, Newcastle upon Tyne, "First-Stage Reconstruction of Portobello Power Station, Edinburgh," T. P. Everett, 6.15 p.m.

RADAR ASSOCIATION

Wed., Feb. 10*th.*—Anatomy Theatre, University College, Gower Street, London, W.1, "Some Unsolved Radar Problems," K. E. Harris, 7.30 p.m.

ROYAL AERONAUTICAL SOCIETY

Thurs., Feb. 11*th.*—Institution of Mechanical Engineers, Storey's Gate, London, S.W.1, "Recent Developments in the Structural Approach to Aero-Elastic Problems," D. Williams, 6 p.m.

SHEFFIELD SOCIETY OF ENGINEERS AND METALLURGISTS

Mon., Feb. 15*th.*—The University, St. George's Square, Sheffield, "The Future of Steel Melting," W. M. Thring, 7.30 p.m.

SOCIETY OF CHEMICAL INDUSTRY

Tues., Feb. 9*th.*—CHEMICAL ENGINEERING GROUP : Geological Society, Burlington House, London, W.1, "Non-Ferrous Metals for the Chemical Engineer," N. P. Inglis, 5.30 p.m.

SOCIETY OF INSTRUMENT TECHNOLOGY

Thurs., Feb. 11*th.*—CONTROL SECTION : Manson House, Portland Place, London, W.1, "Automatic Combustion Control," J. C. Farquhar, 6.30 p.m.